INSTRUMENTED MONITORING OF AERIAL ANOMALIES
A Scientific Approach to the Investigation On Anomalous Atmospheric Light Phenomena

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ABSTRACT. Anomalous atmospheric light phenomena tend to occur recurrently in several places of our planet. Statistical studies show that a phenomenon's real recurrence area can be identified only after pondering reported cases on the population number and on the diffusion of communication media. The main scientific results that have been obtained so far after explorative instrumented missions have been carried out are presented, including the empirical models that have been set up in order to describe the observed reality. Subsequently, a focused theorization is discussed in order to attack the physical problem concerning the structure and the dynamics of "light balls" and the enigma related to the central force that maintains them in spherical shape. Finally, several important issues are discussed regarding methodology, strategy, tactics and interdisciplinary approaches.

Keywords: *anomaly, astrophysics, energy, electromagnetism, geophysics, Hessdalen phenomenon, instrumentation, plasma physics, physical theory, photonics, statistics, research strategy.*

Introduction

Sightings of anomalous light phenomena have been reported from several locations in the world. Most of them have been classified as "earthlights" (Adams, website; see Fig.2). The appearance of these kinds of unidentified aerial phenomena doesn't show a solid structure or the clear evidence of a surface, but it looks more often like a very bright spherically shaped object showing very peculiar characteristics in its structure, motion, and luminosity/colour variations. Most of these events have been documented by visual sightings; less frequently, they have been captured on video. Only a few of them have been monitored using scientific instrumentation. The *first part* of this paper will show, in a statistical way, how the sighting reports of Unidentified Anomalous Phenomena (UAP) in general are spatially dependent on the population number of a given area and temporally dependent on the increase of communication media such as internet and cell phones. Only if these factors are accurately taken into account, a real area of recurrence of UAP of any kind, can be identified and localized precisely, considering that anomalous light phenomena such as "earthlights" of still not fully explained natural origin might be a very consistent part of all the aerial anomalies in general. Some missions to Italian areas are briefly reminded. The *second part* will be dedicated to a description and discussion concerning observations that have been carried out using scientific methods. What do we know scientifically of this kind of aerial anomaly? In fact we must fix in simple terms what we are effectively able to document from observations where data can be effectively recorded. Some working hypotheses on the possible physics of these phenomena are offered but not yet definitively established; this can happen only when obtained data are in sufficient number and when they are collected over a wider range of wavelengths than the ones that have been carried out so far and also guaranteeing a closer simultaneity of different measurements instruments together. The *third part* will deal with the biggest physical problem concerning the way in which such light phenomena show the spherical shape that they have, and a possible physical-mathematical method to model such phenomena in a similar way as in the case of astrophysical objects. The *fourth part* will present a methodological discussion concerning several very important prerequisites that any researcher should follow in this specific field, such as the ability to distinguish the “signal” from the “noise”, research strategies and tactics, the importance to determine once and for all crucial parameters such as target’s distance, the necessity to study light anomalies within a wider context including geophysical/geological and atmospheric factors, and the absolute necessity to proceed in an interdisciplinary way and to make an appropriate subdivision of competences. A choice of optimum instrumentation for research will be presented as well, in which new, specifically aimed, instrumental observations are intended to provide us with a more complete physical picture of what is seen and also to prove or confute working hypotheses concerning the possible physical nature of atmospheric light phenomena.

1 – Statistical considerations

A very recent experiment carried out by this author (Teodorani, 2009b) in order to verify how and how much UAP databases can furnish information of scientific interest, show the following fundamental points of evidence:

A. The almost exponential increase with time of reported sightings concerning anomalous aerial phenomena in general is explainable by the increase with time of communication media such as internet or cell phones (see Fig. 1a), so that, except for some quite well identifiable very short-duration “time-flaps” in history since 1950 up to now that are probably intrinsic to some kind of unidentified phenomenon, judging the general and long-term trend it can be concluded that such kind of anomalies are subject to no real increase in time.

B. The spatial distribution of anomalous aerial phenomena in very specific areas, such as, for instance, the New York and Connecticut States in USA, is totally dependent on the population number concerning people who report such phenomena (see Fig. 1a). This is clearly a sharp selection effect, which doesn’t show at all a real spatial recurrence of strange anomalous aerial events. In fact once a ratio between population number of specific areas – such as cities, towns, townships and hamlets – and number of sightings reported from those specific locations is determined, what we see is that the spatial recurrence of UAP reports diminishes drastically. This can be demonstrated if we take into account only specific locations where, for instance, at least 5 sightings have been reported in the last 60 years. This analysis shows that in such a way we can approach more realistically what can be considered a “spatial recurrence area” for anomalous aerial phenomena. This is clearly only an example (applied only to the NY and CT States), but it demonstrates that such a selective method can be of great help in localizing what can be considered truly an anomaly area, even if represented by a sort of “spatial error box”. In fact what we see from the specifically tested areas is that the real anomaly area of interest is constituted by the Hudson valley at quite specific locations such as Pine Bush, for instance (see Fig. 1b). Considering that most UAP cases are probably a misinterpretation of known natural and/or manmade phenomena (IEA, website; Teodorani, 2008; 2009a; 2010a), it is reasonable to suggest that the residual that can be extracted in such a way may furnish to us information on some possible real anomaly of presumably natural origin that is located around quite specific spots.

The most important of these anomalies have been recently baptized with the name of “earthlights”, showing very well-characterized features (IEA, website). Apart from occasional encounters by pilots (Haines, 2007; NARCAP, website), in general earthlights tend to be reported recurrently in specific areas of Earth. Many of such locations where light phenomena are recurrent are well recognized without any need to make a statistical selection on population. The reliability of sighting reports from these locations is based on the fact that such anomalous light phenomena are seen most often in areas where the population number is very low: probably Hessdalen, a small valley in central Norway inhabited only by 150 persons, is the most famous of these areas in Europe (Strand, 1984). An approximate evaluation of the spatial distribution of "earthlights" in the entire world is shown in Fig 2. Of course the shown maps must be "read" critically due mostly to two precise reasons: 1) some of these areas (maybe most of them) show a light phenomenon that might be explained by prosaic causes in the future and, especially in USA, the reports of light phenomena of earthlight kind can be probably mixed up with some other aerial phenomenon of different and possibly artificial nature (without excluding a possible still undisclosed technology coming from the military; Hourcade, 2007); 2) after cleaning up, in case, these maps from prosaic phenomena mistaken for true anomalies by inexpert reporters, the residual result might anyway represent only an "inferior limit", spatially speaking, of what anomalous is really happening in the world, considering that many of these (still unreported) anomalies might occur within very scarcely inhabited areas or where people is not interested to communicate their existence. Therefore the maps that are shown here are only indicative and must be taken cautiously.

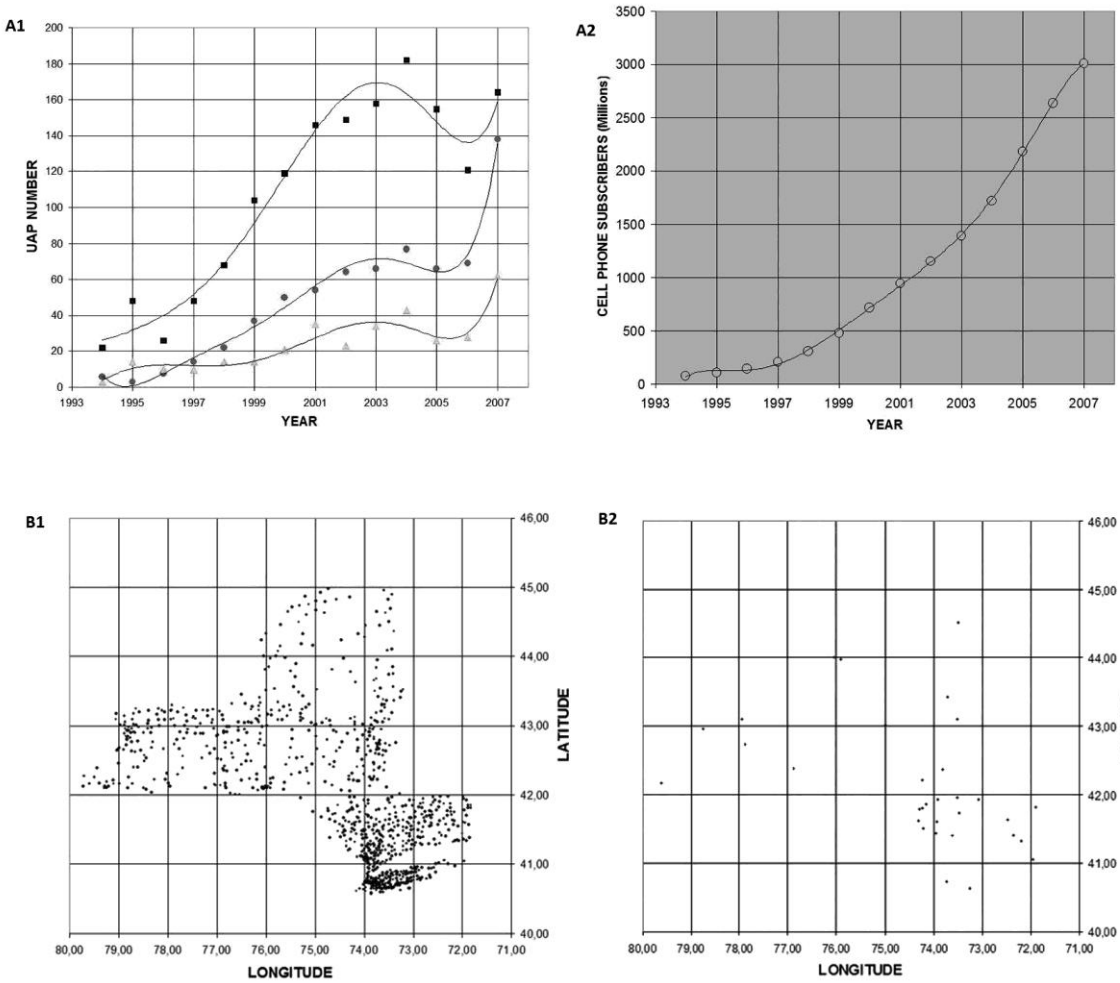

Figure 1A. *A1.*Temporal trend of UAP reported sightings from 1993 to 2007, in the US States of New York (full squares) and Connecticut (full triangles) and in the Canadian Province of Ontario (full circles). *A2.* Increase of the diffusion of cell phone number from 1993 to 2007. *B1.* UAP reported sightings in the New York and Connecticut States. *B2.* Distribution of real UAP sightings, filtered from population number of the locations where anomalies have been apparently reported.

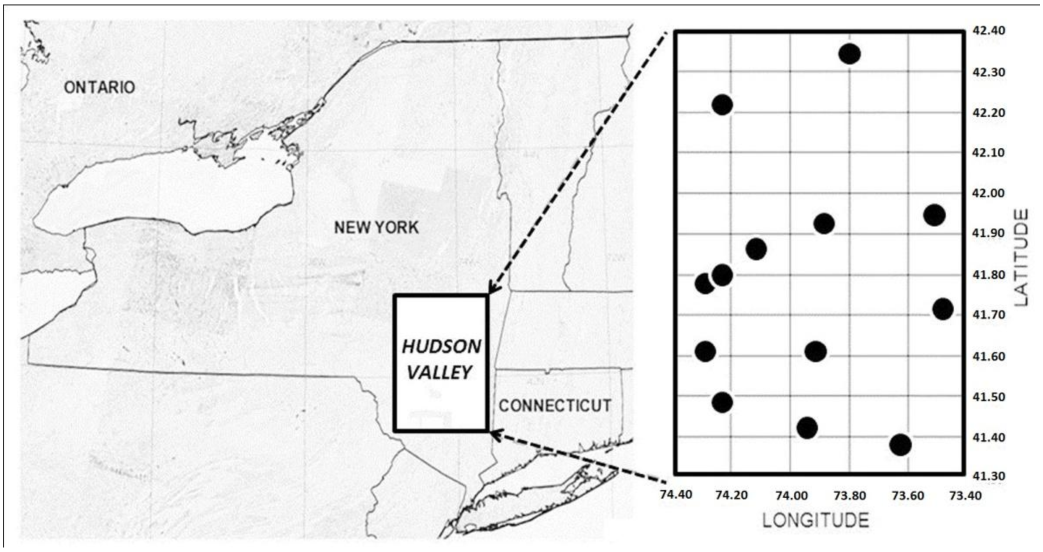

Figure 1B. Concentration of real UAP sightings in a very specific area of New York State (USA).

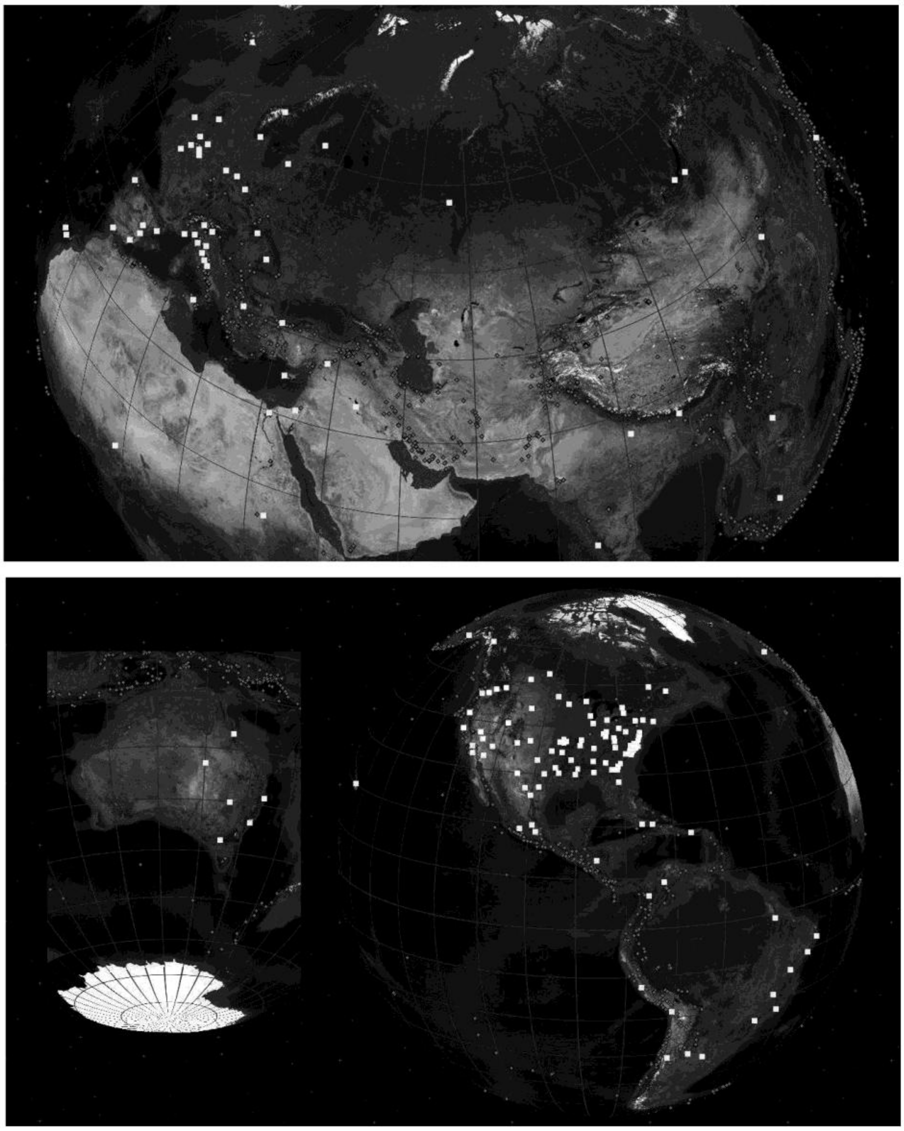

Figure 2. World distribution of locations (clear squares) where, according to existing reports, anomalous light phenomena of the "earthlight" kind occur more often (author's processing). Small dark dots represent fault areas.

2 – Monitoring investigations in Italy

Anomalous light phenomena are quite frequent and recurrent in several places of Italy, with a particular predominance in the geographic area of the Centre-North, just on the Northern part of the Apennines. Several research groups have been contributing (and some of them are doing this still now) in monitoring such phenomena, in some cases using measurement instruments such as VLF-ELF receivers, magnetometers, in addition to video and photography (45° G.R.U., website; CROSS Project, website; ICPH, website; LTPA Observer Project, website; Progetto M.A.L.D.A., website; Project UAP Italia, website; Sassalbo Project, website; SOSO Live Camera, website), including my own research work in this specific field (Teodorani & Nobili, 2004; Teodorani, 2008; see Table 1, see Figs. 4, 5, 6, 9). A lot of work has been done during at least ten years by almost all of the cited organizations and researchers, who are all motivated in this field. The work done in these areas has, particularly in some cases, permitted to make a quite precise cataloguing of the phenomenon's behaviour as it is observed, but (despite some EM instrumentation was used sometimes) no real scientific results and/or conclusions have been obtained so far, except for a quite accurate correlation analysis of reported cases with geological and geophysical parameters (Straser, 2007; 2009). A specific case occurring in Sicily (Canneto di Caronia; Il Mistero di Caronia, website), showed a suspect correlation between the manifestation of highly energetic and beamed microwaves (of probable human origin) and the apparition of "light spheres" in the area: this reminds laboratory experiments where the injection of microwaves in the atmosphere may trigger plasma phenomena of ball lightning kind (Ohtuski & Ofuruton, 1991; Teodorani, 2010b).

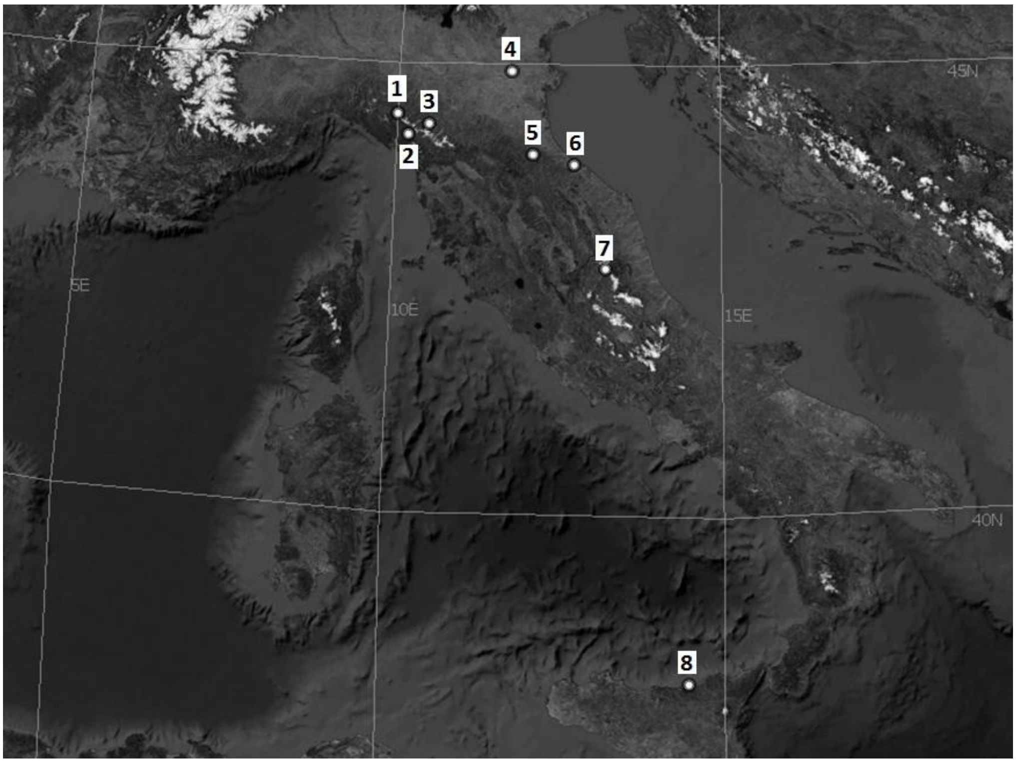

Figure 3. Geographical distribution of the most important locations (so far) in Italy where anomalous light phenomena of the "earthlight" kind occur. ***1***. *Solignano (PR)* – LAT: 44° 36' 49", LONG: 09° 58' 36". ***2***. *Sassalbo (MS)* – LAT: 44° 17' 19", LONG: 10° 11' 49". ***3***. *Pietra di Bismantova (RE)* – LAT: 44° 25' 26", LONG: 10° 24' 49". ***4***. *Lendinara (RO)* – LAT: 45° 05' 00", LONG: 11° 35' 00". ***5***. *Casalbono (FC)* – LAT: 44° 02' 35", LONG: 12° 08' 26". ***6***. *Gabicce (PU)* – LAT: 43° 57' 46", LONG: 12° 46' 22". ***7***. *Monti Sibillini (PG)* – LAT: 42°, 49', 00", LONG: 13° 16' 08". ***8.*** *Canneto di Caronia (ME)* – LAT: 38° 01' 18", LONG: 14° 23' 21" (Latitude is North, Longitude is East).

TABLE. 1 – Locations of anomaly recurrence visited by this author in the course of instrumented missions.

LOCATION	LATITUDE (° ' ")	LONGITUDE (° ' ")	DATE	MISSION DURATION (number of monitored nights)	MISSION TEAM NUMBER	USED INSTRUMENTS	RESULTS (reported anomalies)
Hessdalen (Norway)	62 47 48 N	11 11 28 E	March-April 1994	2 (+ 5 of Scientific Workshop)	10	camera, binoculars	None
Hessdalen (Norway)	62 47 48 N	11 11 28 E	August 2000	10	3 + 2	cameras, VLF, microwave, NVS, videocamera, Geiger, EM meters, radiometer	videos, photos, VLF signals
Hessdalen (Norway)	62 47 48 N	11 11 28 E	July-August 2001	30	5 + 2	cameras, VLF, videocamera, telescope, CCD camera, dispersion grating, Geiger, EM meters	videos, photos, spectra
Hessdalen (Norway)	62 47 48 N	11 11 28 E	August 2002	14	6 + 2	cameras, VLF, radar, dispersion grating, Geigers, videocamera, EM meters	photos, spectra, radar tracks
Arizona Desert (USA)	32 47 48 N	113 32 29 W	March-April 2003	14	3	cameras, telescope, H.R. spectrograph, videocameras, VLF, magnetometers, dispersion grating, EM meters, Geigers, A.S.	photos, videos, telescopic sighting
Montemonaco - Monti Sibillini (Central Italy)	42 53 58 N	13 20 02 E	July 2003	4	2	cameras, EM meter, dispersion grating, Geiger	photos, EM signals, visual sightings
Solignano (PR - Center-North Italy)	44 36 51 N	09 58 36 E	June-July 2004	1 + 4	2 + 2	cameras, EM meter, Geiger, VLF, infrared, dispersion grating	VLF signals, EM signals
Piana di Castelluccio - Monti Sibillini (Central Italy)	42 49 45 N	13 12 30 E	July 2005	4	2	cameras, EM meter, Geiger, VLF, infrared, dispersion grating	visual sightings, VLF signals, photos
Casalbono (FC – Center-North Italy)	44 02 35 N	12 08 26 E	August 2005	1	1	camera, EM meter, VLF, dispersion grating, Geiger	visual sighting, photo
Gabicce (PU _ Center-North Italy)	43 57 46 N	12 46 22 E	January 2006	1 + 1	2	camera, EM meter, dispersion grating, Geiger	visual sighting
Piana di Castelluccio - Monti Sibillini (Central Italy)	42 49 45 N	13 12 30 E	July 2007	2	2	camera, EM meter, VLF, dispersion grating, Geiger	VLF signals
Pietra di Bismantova (Center-North Italy)	44 25 00 N	10 25 00 E	July 2008	4	2	camera, EM meter, VLF, dispersion grating, EEG, Geiger	visual sighting, photo
Montefiorino-Bismantova (Center-North Italy)	44 21 05 N	10 37 24 E	July 2009	2	3	cameras, dispersion grating, VLF, EEG, Laser	visual sightings, photos, visual spectrum
Ontario (Canada)	43 46 26 N	79 56 44 W	July-August 2009	17	2	cameras, dispersion grating, BEFEC, videocameras, EM meter, Geiger, VLF, Lasers, radio scanner	visual sighting, VLF signals

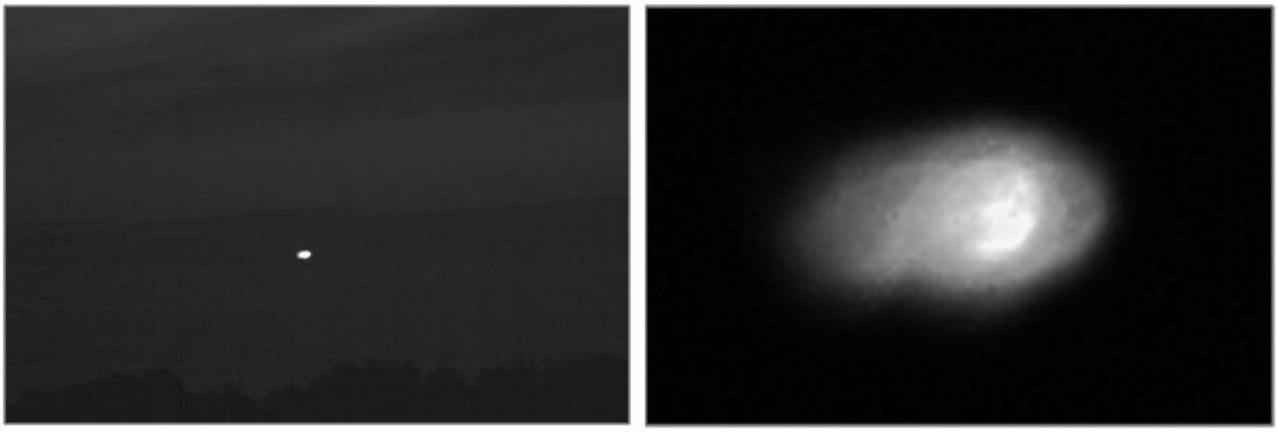

Figure 4. Light phenomenon photographed by this author in Casalbono (FC) in August 2005, using a *Fuji Finepix S-2 Pro* reflex digital camera equipped with a 70-300 mm lens . The time was about 22:30 local time. Zoomed and processed image is shown on the right.

Figure 5. Suspect transient fast moving earthlight photographed by this author using a *Fuji Finepix S-2 Pro* reflex digital camera equipped with a 70-300 mm lens. Location of anomaly is on the top of a flat mountain called Pietra di Bismantova (RE), Italian Northern Apennine area, on the right side. Enhancement is shown below. The date is July, 8, 2009, at about 23:00 local time. Photo was taken from a spot located a few Km away from Montefiorino (MO).

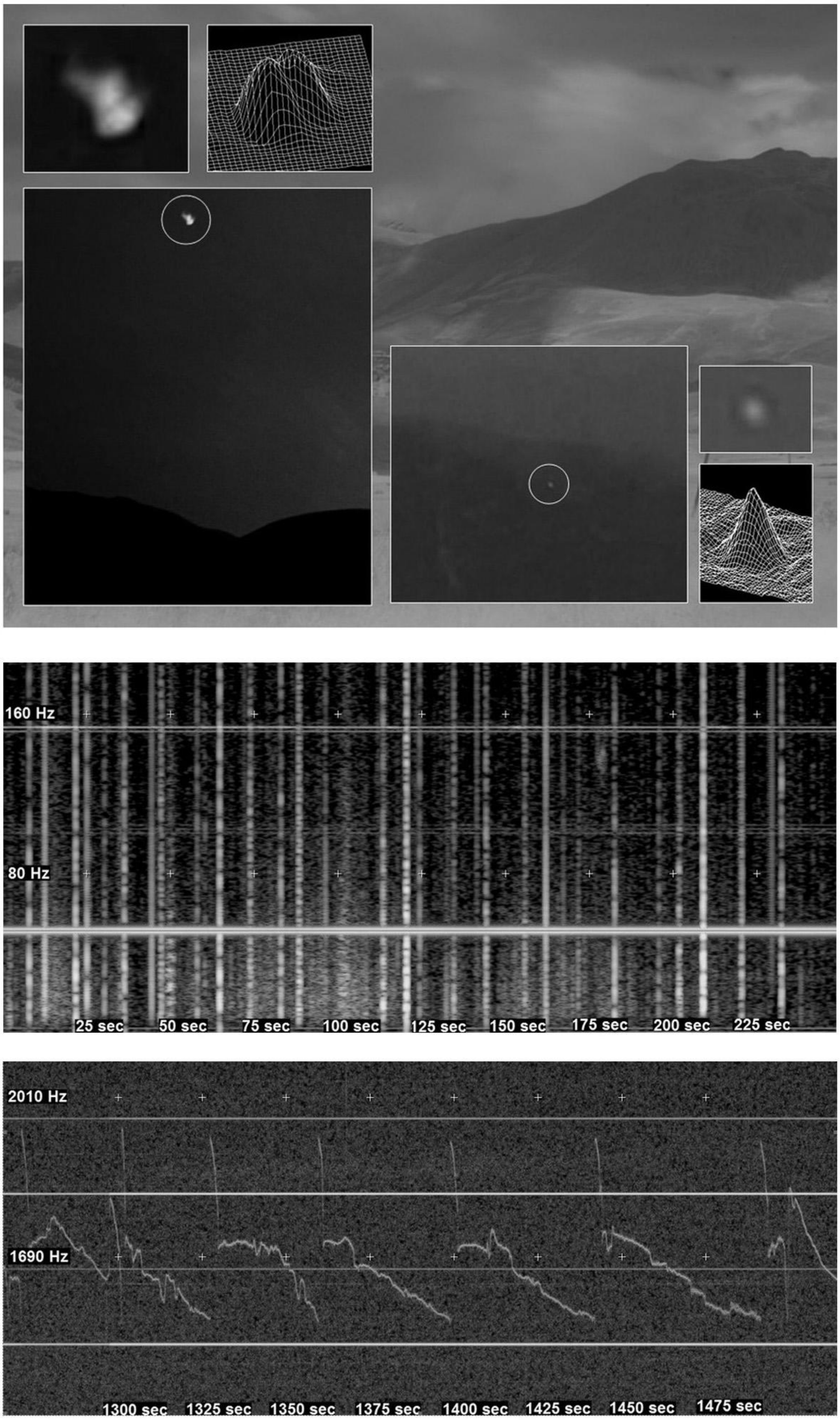

Figure 6. *Up*. An example of a light phenomenon photographed by this author in Monti Sibillini (Central Italy), July 2003 and 2005. *Centre.* VLF spectrogram acquired by this author in Monti Sibillini, July 2005, showing a high level of electrostatic activity (vertical lines known as "spherics") in the area. *Down*. VLF spectrogram acquired by this author in Solignano (PR, Centre-North of Italy)), July 2004, showing still unexplained signals (in both cases the Y axis represents frequency, while the X axis represents time).

3 – Scientific observations in Hessdalen, Norway

Spherical shaped light phenomena (when not already identified as being dubious videos on Youtube or other channels of popular media) have been confirmed as an existent phenomenon through scientific studies that have been carried out at locations where this kind of phenomenon has shown itself to be reasonably recurrent (Adams, 2007; Akers, website; Bunnell, 2003; Marfa Lights Research, website; Long, 1990; Orbwatch, website; Project Hessdalen, website; Rutledge, 1981; Stephan et al., 2009; Strand, 1984, 1996; Straser, 2007; Teodorani, 2004, 2005, 2008; Warren, 2004). The Hessdalen valley in Norway might be probably considered of prototype of these special locations, not just due to the many events that are reported, photographed, and videoed (and sometimes occasionally measured) but because of the existence of a permanent measuring station there and the occurrence of many international missions in the area. This location has become a sort of “laboratory area” that is very well suited for the investigations of physical scientists in general (Project Hessdalen, website). It can now be confirmed that similar recurring phenomena also have been sighted in other areas of the world: for instance the Brown Mountain (Warren, 2004) and Marfa light phenomena (Marfa Lights Research, website; Stephan et al., 2009) in the U.S.A. and the Min-min phenomena in Australia (Strand, 1996) are quite well known and have been scientifically monitored.

Concerning the research carried out by this author and some of his collaborators in Hessdalen (Teodorani, 2004, 2008), it has been possible to depict a provisional but quite precise observational scenario concerning the characteristics shown by these luminous spheres, the most important of which probably are the following ones:

1. They are most often of spherical shape, of different colours (mostly white), often of long duration (up to 30-60 min, spaced out by periods of “off” and “on” phases), and relatively large dimensions (1-10 meters). Their duration and dimensions are respectively much shorter and smaller than apparently similar phenomena such as ball lightning, given the empirical fact that duration and dimensions are correlated (Stenhoff, 1999). These phenomena have been provisionally ascribed to the class of “earthlights” (IEA, website). Yet such a phenomenon, together with ball lightning, are the only anomalous aerial phenomena whose existence has been effectively confirmed by scientific methods of observation and statistical analysis.

2. They are often able to emit a high level of radiant energy. The most credible measurement attributed to them a power on the order of 20 KW in the optical spectrum (Teodorani, 2004). The brief description which follows here concerns the chosen method. In such a case the absolute radiant power P was obtained by using the following equation (Maccabee, 1999):

$$P = 4\pi \cdot d^2 \cdot \frac{E}{\tau \cdot \frac{\pi}{4} \cdot \left(\frac{F}{f}\right)^2 \cdot T} \cdot e^{\frac{3.9 \cdot d}{V}}$$

Where: $\boldsymbol{d}$ is the distance (in m), $\boldsymbol{E = I \; x \; A}$ (in lm·sec) is the total energy received by the film (for a 100 ASA Kodak Ektachrome slide) integrated over the image area, $\boldsymbol{I}$ is the energy per unit area of the image (in lm·sec m^{-2}), $\boldsymbol{A}$ is the image area (in m^2), $\boldsymbol{V}$ is the optical visibility distance (in m), $\boldsymbol{\tau}$ is the duration of the light phenomenon (in sec), $\boldsymbol{F}$ and $\boldsymbol{f}$ are respectively the focal length and the f-number of the camera (the ratio $\boldsymbol{D = F / f}$ gives the aperture diameter of the lens, in m^2), $\boldsymbol{T}$ is the lens transmission factor.

Less credible evaluations report (guessed, not measured) values of 1 MW. These phenomena are most often unstable in luminosity and are subject to light variability at the rate of a few seconds or less, with no clear periodicity, i.e., irregular. They can remain on for some minutes (while pulsating) and then turn off during a similar duration. When they are turned off in the visible spectrum they might still be (sometimes very strongly) visible if a night vision system or the night-shot option of a video camera is used.

3. The mechanism that determines their irregular pulsation, which causes an only apparent increase of the light surface, is now quite well documented from instrumental observations. The inflation is not due to the expansion of the spheres themselves but to the sudden appearance of many smaller spheres (see Figs. 7, 10) that gather together around a common barycentre and that multiply and "reproduce" themselves in a very short period of time following a mode that is very similar to cellular multiplication. Due to this behaviour an in-depth study is presently suggested in order to verify the possible evidence of a "plasma life form" (Tsytovich et al., 2007). The observed multiplication of secondary spheres forms a "light cluster" and determines a strong luminosity increase that is caused by the increase of the total surface emitting area, whose angular diameter is given by the empirical formula:

$$\alpha \approx \frac{D}{d} = \frac{2}{d} \cdot \left(\frac{L_E}{4\pi \cdot K} \right)^{\frac{1}{2}}$$

where $D = 2R$ is the intrinsic diameter of the light cluster (R is its intrinsic radius), d is the distance from the observer, $L_E = 4\pi \cdot R^2 \cdot K$ is the luminous power emitted in the optical wavelength and K is the crucial constant of the problem, as both photometric and spectroscopic observations give $K = T$, where T is the temperature. It is therefore clear that just the radius R is the only parameter that determines the intrinsic luminosity variation, assuming that here we deal with an isotropic radiator and that the observer, at distance d, perceives a "received luminous power" given by $L_R \propto L_E / d^2$. This means that the light phenomenon behaves (at least at the time of measurements) isothermally, with no adiabatic expansion as a cooling mechanism. This is confirmed both by photometric data, where luminosity increases linearly with surface area (see Fig. 8), and by spectroscopic data, where the main observed spectral features remain unchanged when luminosity varies. The nucleus of such a cluster of spheres seems to be animated by apparently electrostatic forces, which determine totally erratic movements around the nucleus or their sudden appearances and disappearances, whose origin might be due to a sort of "central force" able to trap the "dancing spheres" (Teodorani, 2008; see Fig. 11) or to an external electrochemical mechanism mediated by water vapour and aerosols that is able to confine them from the outside (Teodorani, 2004, 2008; Turner, 2003; see Fig. 11). Occasionally some of these light clusters are able to eject some of the secondary spheres following a sort of almost "instantaneous motion". This behaviour suggests a type of electro-statically driven kinematics and that all the components of the light complex are plasma spheres, whose heat is maintained constant by a force that prevents the heated gas from cooling: the "off-luminosity" phases are suspected to be one of the main self-regulating modes that prevents these spheres from liberating their energy explosively when the temperature is too high within a too small confining volume. Nevertheless the clustering behaviour can be observed only when these light phenomena are observed with a zoom lens or a telescope, or when the distance away from them is very little. When seen with the naked eye these light phenomena appear just like single occasionally "inflating" spheres, but upon more careful observation shows that they are composed of many secondary spheres whose appearance and disappearance cause the observed light pulsation effect. In addition to the Hessdalen case, a similar behaviour, such as the one described here, has been reported by witnesses who observed and videoed the same kind of phenomenon in the case of the Min-min lights in Australia (Strand, 1996) and the Hornet and Paulding lights in the U.S.A. (Teodorani, 2008).

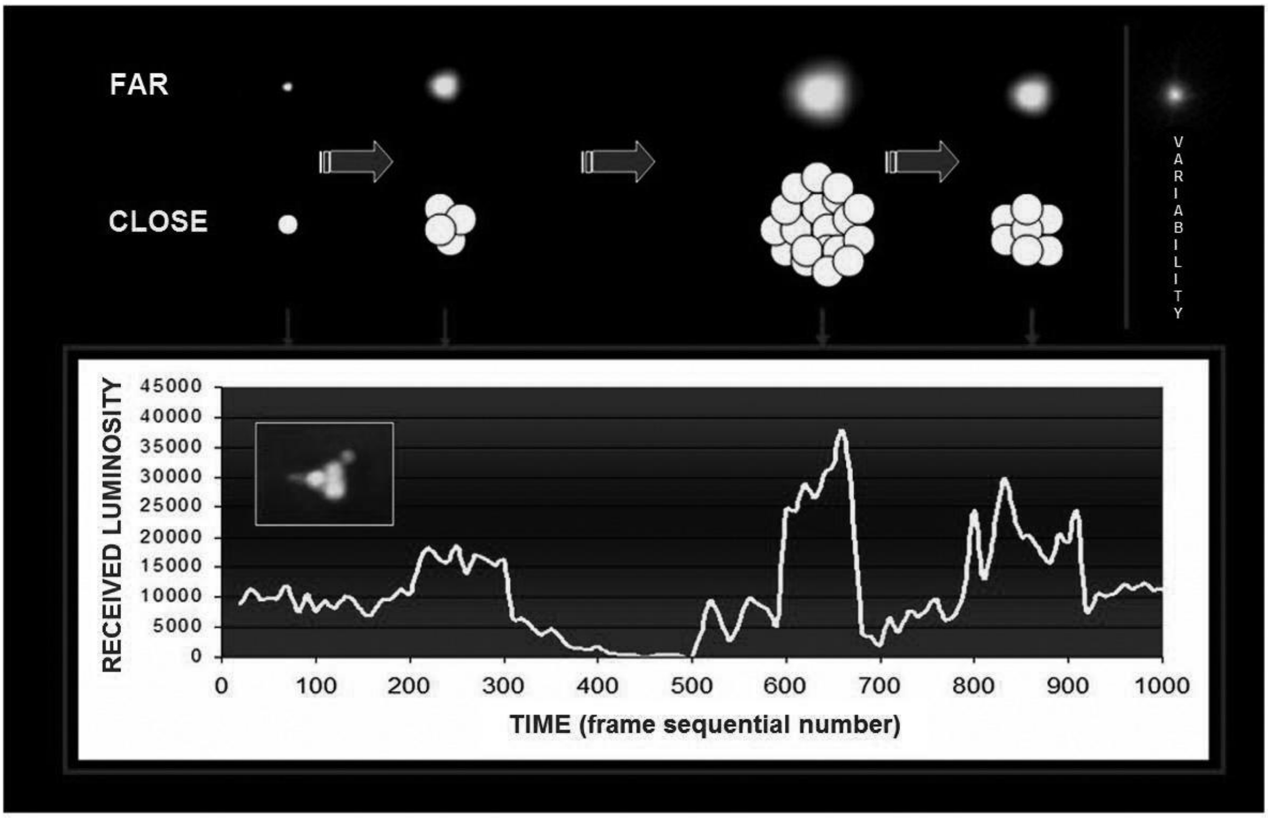

Figure 7. The "clustering effect" manifested by the light spheres observed in Hessdalen: observed "light spheres" are in reality composed of many secondary spheres, whose increase in number is the main cause of light variability (as shown by the diagram in the lower part of this figure).

4. The 3-D light distribution of the overall light phenomenon is not usually of Gaussian kind (typically represented by a smoothed bell-shaped curve where luminosity decreases exponentially away from the nucleus) such as in the case of a more typical spherically-shaped plasma concentration as is found associated with a typical star (Limb darkening, website), but it is quite rectilinear, as it would be expected by an uniformly illuminated solid (Teodorani, 2004). Apparent solidity can be more successfully explained by a model where electrochemical forces intervene in confining the plasma (Teodorani, 2004, 2008; Turner, 2003).

5. The very few optical spectra that have been obtained of the light phenomenon do not show a "unified pattern" (such as that of a star of a given spectral type, for instance). This means that such a phenomenon doesn't contain specific chemical abundances of its own but its spectrum is strictly dependent on temperature, density and pressure of the air where the localized heating occurs, on the dust dispersion in the air, and also on the location of the light phenomenon relative to the ground. In fact, if the phenomenon occurs close to the ground or if some earth-particles are occasionally suspended in the air, as happens very often (see Fig. 10), it can produce a spectrum that reflects the composition of the soil (Teodorani, 2008). Such a spectrum can be highly time-variable according to the abundance of chemical elements encountered in its path by the plasma ball (Warren, 2004). Sometimes, if mold spores are approached by the onset of a localized plasma

condition of the surrounding air the optical spectra can simulate semi-conductive characteristics showing a light-emitting diode- (LED) like spectrum (Teodorani, 2004). Therefore spectra vary according to several parameters and do not constitute a fixed "unchangeable identity card" of these objects (Teodorani, 2008; Warren, 2004).

6. Quite often the light phenomenon presents a radar track (Strand, 1984), and anomalous radar signatures also can be recorded when a luminous phenomenon is not in sight (Montebugnoli et al., 2002). This is very interesting because it might indirectly demonstrate that when the plasmoid is invisible it is also (possibly) still emitting in the infrared wavelengths as low-energy plasma. This might be further supported by the fact that – as it has been reported indeed – when the phenomenon is in its off phases in the optical it can be visible using an image intensifier (Teodorani, 2008).

7. Most phenomena that have been studied so far possess a spherical shape, but a few cases do exist in which other shapes have been encountered and where such a spherical shape changes into something else (Teodorani, 2008).

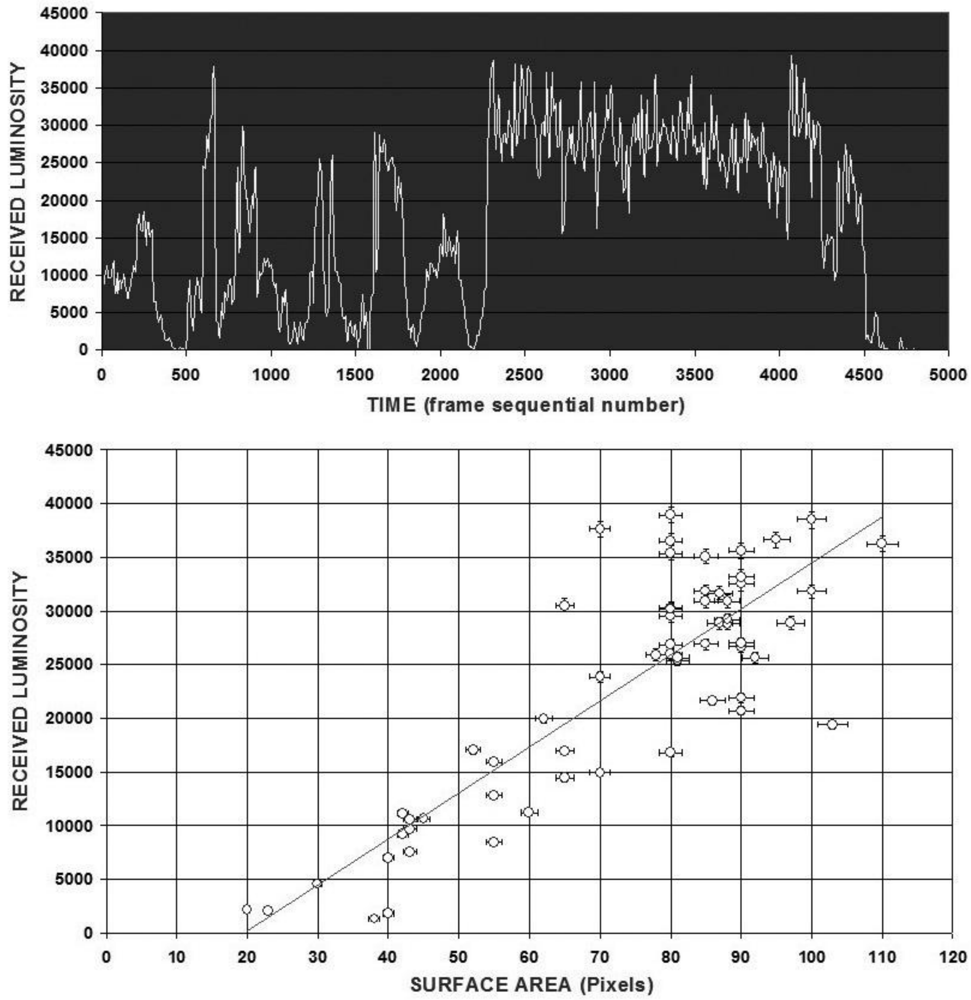

Figure 8. *Up*. Time variability during 3 minutes of the received luminosity (numeral counts) of one light phenomenon (composed of many secondary clustered spheres) observed in Hessdalen, July 2001. Data were obtained using a Canon TM-1 professional videocamera. Received luminosity has been calculated using the technique of "aperture photometry", where a computer generated aperture over a grid of pixels is used and the numeral counts within the aperture are added up. *Down*. Correlation between received luminosity and surface area of a light phenomenon characterized by a "clustering effect".

8. A time correlation with magnetometric measurements (Strand, 1984, 1996) and/or with VLF-ELF measurements is occasionally confirmed and/or strongly suspected (Teodorani, 2004, 2008). Possibly magnetic field intensity and VLF-ELF emission is strictly dependent on the distance to the observer and/or to intrinsic properties, which might change over time. In some cases the appearance of light phenomena seems to be correlated with an enhancement of the amplitude of signals of well-known ionospheric origin (Teodorani, 2008).

9. There is no clear scientific proof that such phenomena are subject to colour change when their speed varies. On the contrary, it can often happen that spheres of different colours (most often white, red and blue) coexist together in a static configuration (see Fig. 10, Teodorani, 2004).

10. Many witnesses report that such phenomena very often tend to approach people and/or animals in a way that goes beyond a simple mechanism of electrostatic attraction. In fact biophysical studies, to be possibly correlated with the findings coming from recent experimental research (Tsytovich, 2007), have been deeply encouraged (Teodorani, 2008).

Figure 9. Some of the portable instruments that are currently used more frequently by this author: portable optical photographic and spectrographic equipment, telescopes and catadioptric lenses, polarizing and infrared filters, VLF-ELF spectrometer, analogical magnetometer, Geiger, Laser and EEG.

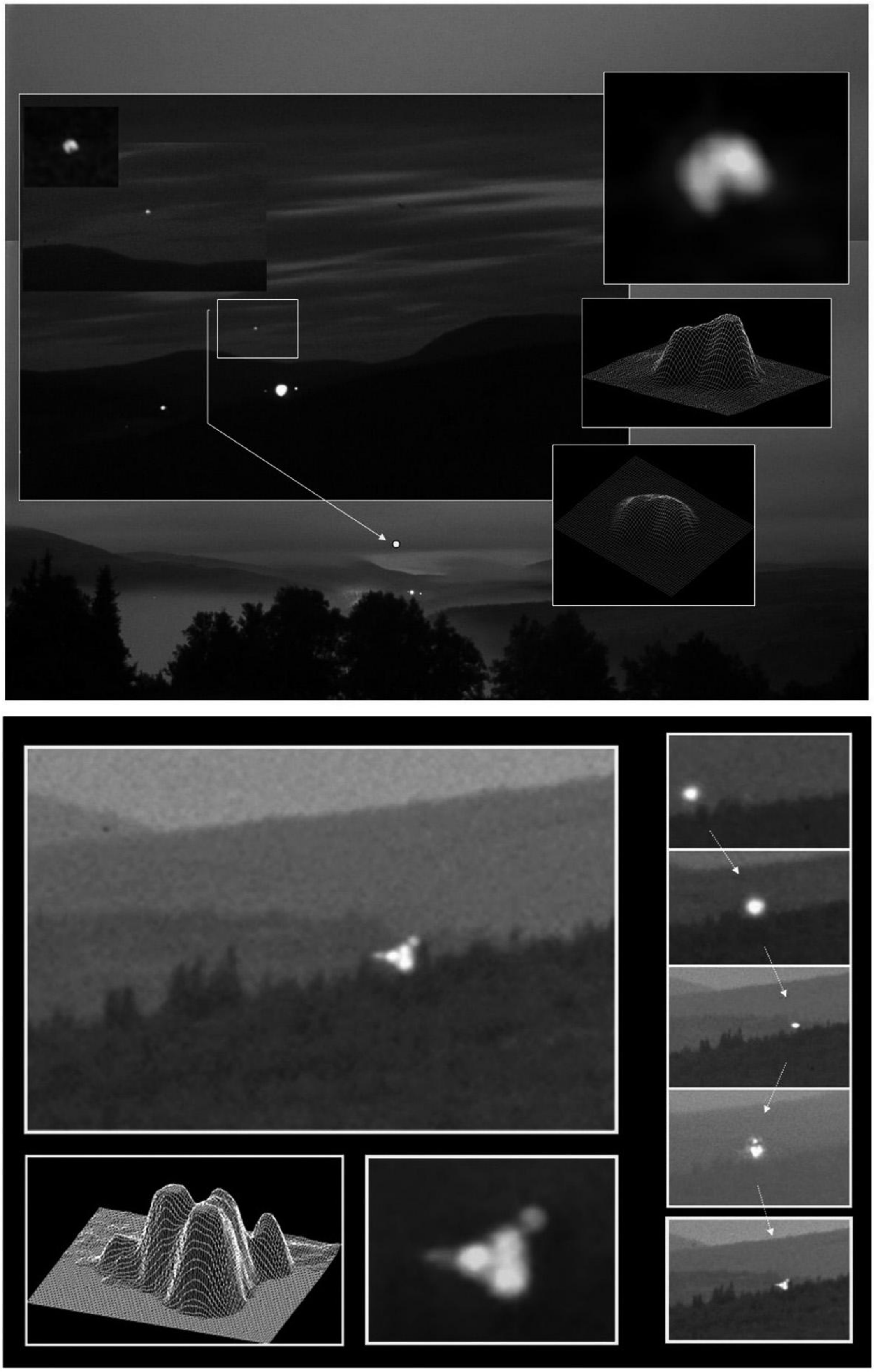

Figure 10. *Up*. An example of a light phenomenon photographed by this author in Hessdalen, Norway, July 2001, using a conventional *Yashika 107 Multi-Program* reflex film camera equipped with a 35-70 mm zoom lens. *Down left.* An example of a multiple light-ball photographed by this author in Hessdalen, Norway, July 2002, using a conventional *Praktica BX-20* reflex film camera equipped with a 270 mm lens. The three brighter lights are white, the upper light is red and the fainter light on the left is blue. *Down right*. Shape and dimensional variation is shown, after using shorter focal lengths.

These are the essential observational elements that can be technically described based upon observations carried out so far according, at least, to the investigations of this author and his comparative studies with other investigators. Instrumented missions carried out by this author to other parts of the world where anomalous light phenomena happen recurrently, such as the Arizona desert, the Ontario area in Canada, and some Italian areas, have permitted to collect some data (Teodorani, 2005; 2008; 2009b; Teodorani & Nobili, 2004) concerning testimony of particularly spectacular events, photos of light anomalies and presumably related EM fields. These missions, anyway, though enhancing quite strongly the technical expertise of deploying measurement instruments on the field, didn't permit yet to construct a self-consistent and coherent picture as it happened during the missions to Hessdalen.

It is beyond the scope of this part of the presentation to discuss in detail the theories and/or working hypotheses that explain the triggering causes and confinement mechanisms of such plasma spheres. It can only be mentioned that the best candidate theories for the triggering causes of these light balls are so far of a geophysical nature, in particular piezoelectricity, triboluminescence and the more recent and complete P-hole theory (Freund, 2003; Teodorani, 2004, 2008), while the proposed plasma confinement mechanisms have involved several kinds of central forces of magnetic, electromagnetic, gravitational and electrochemical nature (Fryberger, 1997; Smirnov, 1994; Teodorani & Strand, 1998; Teodorani, 2004, 2008; Turner, 2003; Zou, 1995). The schematics of two possible models proposed by this author are presented in Fig. 11.

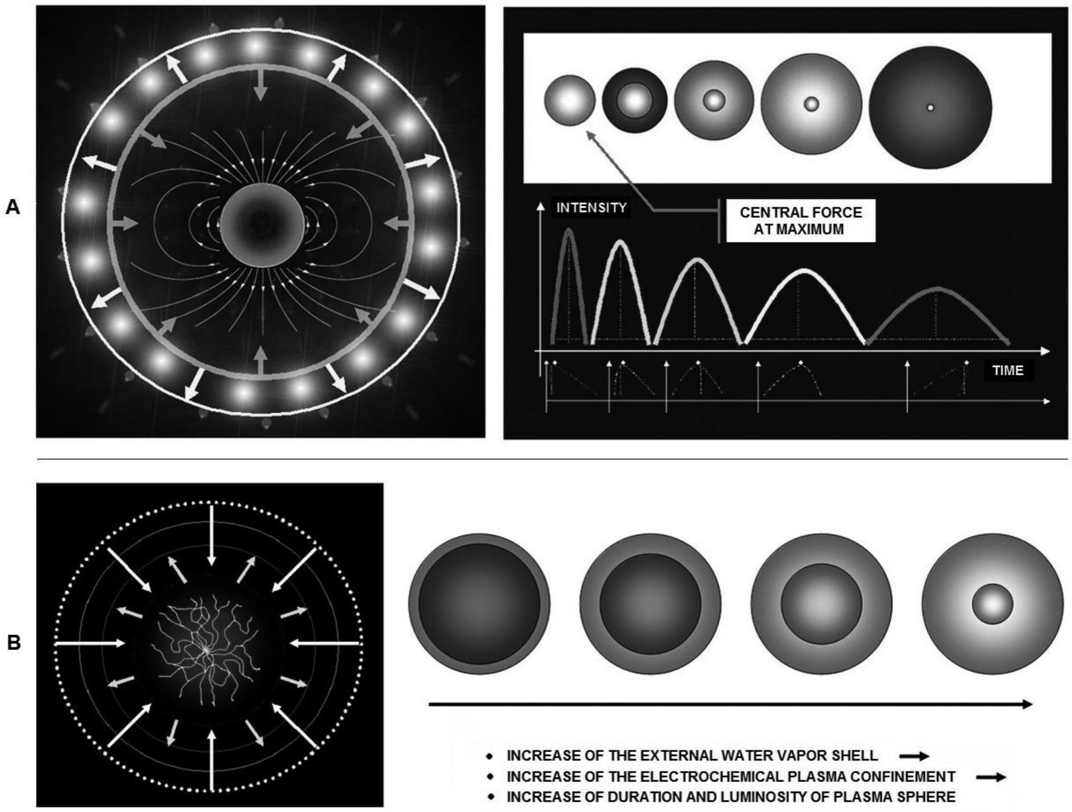

Figure 11. Two alternative models proposed by this author in order to explain plasma confinement mechanisms inside a "light sphere". *Model A*. Plasma trapped by a central force represented by a strong magnetic field in the centre of the light ball, where an adiabatic expansion and cooling of the plasma sphere occurs when the magnetic force decreases. *Model B*. Plasma confined from outside by inward electrochemical forces (derived from a theory by chemical physicist David Turner: [Turner, 2003]) mediated by increasing water vapour and aerosols balancing the outward adiabatic expansion of the plasma.

4 – The main physical problem for "light balls"

One way to attack the physics of the problem (we do not consider here electrochemical mechanisms, but rather a purely physical plasma ball) can, in principle, be quantified by considering an essential set of equations, which do not differ substantially from the ones normally used in stellar physics (Kippenhahn & Weigert, 1994), where equilibrium between several physical forces is considered. The main concept that must be described deals with a balance between an inward central force of whatever nature and the outward pressure of the plasma gas. We now want to try to establish quantitatively the structure of a plasma spheroid. Assuming that the plasma is represented by a high-temperature perfect gas[1] having pressure P, temperature T, mass M and density ρ, that the sphere containing it has a radius r, and that the gas pressure is counterbalanced by a "central force" of whatever nature that is able to maintain the stability of the plasma sphere, we can fix the following set of simple equations:

$$\frac{dP(r)}{dr} = -\frac{\eta \cdot M \cdot \rho(r)}{r^n}$$ *Hydrostatic Equilibrium*

Where η is a constant depending on the central force keeping all the particles together (to be still defined because we have no confirmation yet of the real mechanism, but we have only hypotheses related to it), and n is an exponent that determines the way in which this force varies with the radius of the sphere (if this force is gravity, as in the stars, n = 2).

$$\frac{dL(r)}{dr} = 4\pi \cdot r^2 \cdot \rho(r) \cdot \varepsilon$$ *Energy Generation*

Where L is the luminous energy of a plasma sphere characterized by a thermodynamic equilibrium between matter and radiation, and ε is a coefficient of "energy generation" (in the case of stars this energy is constituted by nuclear fusion), which might be due to several factors according to the model that is used to describe that which appears as a self-regulated structure. Assuming that the plasma sphere is an isotropic radiator, then its bolometric luminosity (Lang, 1998) (at all frequencies from X-rays to radio waves, passing through the optical) is given by:

$$L_B = 4\pi \cdot r^2 \cdot \sigma \cdot T^4$$ *Bolometric Luminosity*

Where σ is the Stefan-Boltzmann constant. This is quite an important equation because it relates intrinsic physical properties such as T to radiant properties such as L_B . Clearly L_B corresponds to the "absolute luminosity" that can be known only if we are able to measure the distance d of the plasma sphere and the apparent luminosity L_A through observations, where L_A is given by $L_A = L_B / 4\pi \cdot d^2$. Moreover, assuming that what we observe in the distance is not the intrinsic radius of the sphere but only the angular radius $\alpha \approx r / d$, we realize that if we measure α and we derive d using several methods (radar, Laser range finding, triangulation) we are then in a position to obtain r, which permits us to use practically the equations that have been posed.
Assuming that the produced luminosity is related to Temperature, we also have:

[1] **Perfect gas**. An ideal gas where: 1) the particles composing it are all point-like; 2) collisions between them are elastic (namely, characterized by no energy dispersion); 3) no interaction forces in distance exist between particles. All this is described by a general and fundamental thermodynamic law given by $P \cdot V = n \cdot R \cdot T$, where P, V and T are respectively the pressure, the volume and the temperature of the gas, n is the amount of substance of the gas (in moles) and R is a constant.

$$\frac{dT}{dr} \propto -\frac{L}{\beta \cdot 4\pi \cdot r^2}$$ *Energy Transport*

Where β is a coefficient to be specifically defined in the case of plasma spheres (in the case of stars a thermal conductivity coefficient is used).

Here we have prepared an essential set of equations that define the "plasma sphere structure", after assuming that a plasma sphere can be considered as a sort of "mini-star", and after showing how observed parameters are linked with intrinsic physical parameters. But, differently from the case of stars, here we do not yet know the boundary and initial conditions with sufficient precision, which must remain arbitrary at the present time, if we want to integrate this system of differential equations and if we want to see the evolution of the involved physical parameters with independent variables such as the radius and the time (Kippenhahn & Weigert, 1994).

Moreover it must be pointed out that we considered only the way in which luminosity is related to temperature, but still we do not know exactly how these parameters are related to electrical and/or magnetic parameters. In fact, due to some observed facts concerning plasma spheres several reasons exist to suggest that plasma spheres are also electrical/magnetic physical systems. The inclusion of these parameters (we do not know yet how exactly) inside previous equations renders the problem quite complicated and the solution of a complete set of equations less than easy (yet not impossible). This is only a semi-quantitative reasoning aimed at stimulating a possibly complete way to fix the problem to be solved quantitatively in a subsequent phase.

We clearly see here that, at the present point, what is important is to elaborate a specific theory that explains the way in which light-balls are "self contained" (we are not yet in a condition to do this as there is not yet a sufficient and quantitative/predictable match between theory and observations, the last ones of which are still lacking). Concerning this it is absolutely necessary to focus on the nucleus of the problem that can be synthesized by some important considerations that follow. To appear in such a way, a light ball allegedly composed of some kind of plasma, can be the result of two opposite forces, one inward and the other one outward. It is obviously much easier to know the nature of the second: if the light ball is made of plasma the outward force must be represented by the external pressure of adiabatic naturally expanding ionized/excited gases. The main difficulty is to try to deduce what is the inward force: we know that in stars this is the gravitational force, but we do not know what the counterpart in these plasma balls is. And it is highly premature to insert work-hypotheses inside equations: we can do that only and if we'll have at our disposal more experimental data. Only in that case we'll be in a condition to determine the value of the posed coefficients η, ε and β and exponent n so that it would be time to integrate the equations numerically for values of the radius r ranging from $r = 0$ to $r = R$, in order to see how after setting fixed values for variables such as the radius r all the other physical variables such as pressure P, temperature T, and luminosity L vary. In such a way we would be in a condition to predict the "internal structure" of a light ball after inserting some observed values such as r and L. This procedure might in principle allow us to build up a predictable picture in the dominion of space, assuming several dimensional configurations for light balls. This might help us to verify how and if the luminosity L parameter is linked with the radius r, for instance. Of course the success of this potential mathematical simulation will totally depend on the data that we are able to obtain from observations, reminding that our ability to obtain observationally parameters such as r and L will only depend on the accuracy with which we'll be able to measure the distance d of the phenomenon and its angular diameter θ. The following simple equations show how observed data concerning the light phenomenon are related to the intrinsic data of the phenomenon:

$$L \propto 4\pi \cdot \frac{R^2}{d^2} \cdot T^2 \qquad \Theta \propto \frac{2R}{d}$$

Where: L is the received luminosity, R is the maximum value of the radius acquired by the light ball, T the temperature, ***and d*** is the distance from the observer. Figure 12 shows the situation intuitively.

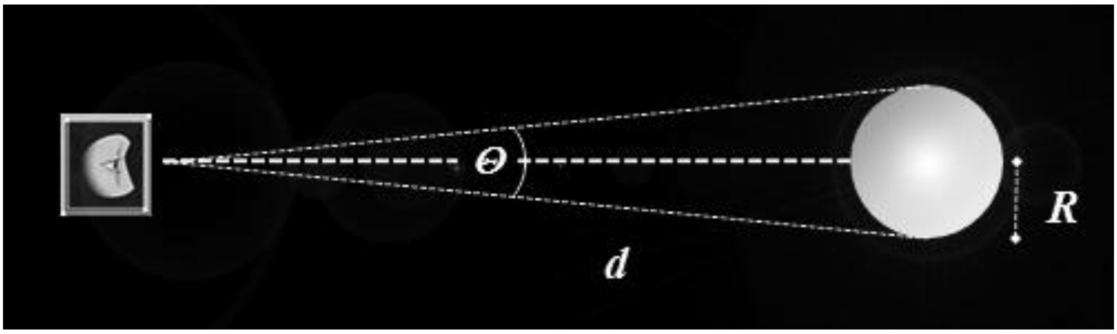

Figure 12. The way in which a light ball is observed in distance.

The observed reality is, anyway, more complicated as light balls are often observed in clusters and not only singularly. Therefore the system of equations for mathematical simulation must be extended to all of the components of the complex. Consequently what we may study is not only L but rather the "integrated luminosity" given by:

$$L_{INT} = \sum_{i=1}^{i=n} L_i$$

Where n is the maximum number of the components of a "light ball cluster". Clearly all this means that mathematical modelling must be extended to all the complex of light balls. As a light complex is not composed of a constant number of light balls but rather by a number that is highly variable in time (on a very short timescale), a new modelling is needed here dealing with the main source of light ball variability. This means that an "evolutionary process" for a light ball complex must be taken into strict account in order to simulate the mechanism of light variability, after modelling the spatial and energetic structure of light ball components all together. In such a way observations must furnish to us the (approximate) period Π of light variability and/or its variation in time, namely: $\dot{\Pi} = d\Pi/dt$ where t is the time variable. Period increase or decrease can be represented by a "pulse-up" and a "pulse-down", respectively. In such a way we can derive a simple general equation describing the way in which the luminosity varies according to the observed time-variation in the case that the pulsation period (in addition to a constant variability represented by Π) is subject to a "pulse-up" or a "pulse-down" too, which can be given by:

$$\frac{\dot{\Pi}}{\Pi} \propto \Pi \cdot L_{INT}{}^{m}$$

Where m is an exponent to be determined directly from observations. Of course the empirical data that are obtained from observations, when they are in sufficient number, must be simulated mathematically, in order to be in a condition to predict the overall phenomenon's behaviour in time. This operation is not so simple, but in principle it is feasible for future research, as soon as many more data can be rendered available with reasonable constancy both in Hessdalen and in other places of the world where such phenomena are recurrent.

Finally, similarly to a well known mathematical treatment of the radiation emitted by planetary nebulae in astrophysics, a photo-ionization factor should be taken into account as well, above all if the photons emitted by a single plasma ball are particularly energetic, especially if they radiate in the ultraviolet. In such a case we can define this quantity:

$$R_I = \left(\frac{3 \cdot N_*}{4\pi \cdot \gamma \cdot n_P^{\,2}} \right)^{\frac{1}{3}} \qquad \textit{Ionization Radius}$$

Where N_* is the number of ionizing photons emitted in the unit time by the plasma sphere, γ is the recombination coefficient, and n_P is the number of atmospheric particles involved in the ionization process [2]. Due to the spherical shape, this plasma object in general is expected to act isotropically, namely radiating in the same way in all directions [3]. Clearly clusters composed of many spherical plasmoids are expected to produce many interacting "ionization influence spheres", which should exert a marked influence on the surrounding atmosphere: this physical problem might be named: "circum-ball medium physics". The method of study is substantially similar to the one used to study planetary nebulae or similar astrophysical objects, the difference being that the circumstellar medium is replaced by the circum-ball terrestrial atmosphere.

So far we considered only thermal forces just to simplify the physical problem. What happens if we add a magnetic component to the plasma? It is well known from Alfvèn theory (Lang, 1998) that magnetic force lines (if a magnetic field is effectively present in the plasma) are "frozen" inside the plasma. This has been studied in plasma formations (such as nebulae) in interstellar space (Hiltner et al., 1962; Lang, 1998). The inclusion of a magnetic field yields several important facts. Due to the existence of a factor given by "magnetic pressure" the dynamic properties of matter are influenced by this, in addition to mechanical pressure [4]. Let's now consider a plasma

[2] **Density of atmospheric chemical elements and electricity**. Atmospheric gaseous constituents tend to vary as a function of geometric altitude during periods of minimum and maximum solar activity (U.S. Standard Atmosphere, website). An electrical component might also be responsible for this and perhaps affect the frequency of occurrence of plasma spheres. A new physical theory concerning a global electrical and plasma nature of the Universe (involving Earth's atmosphere as well) has been proposed and is being currently developed (Peratt, 2000). This theory is currently controversial because it tends to dismantle many of our generally accepted paradigms in astronomy, cosmology and atmospheric physics, but it should be examined in more detail.

[3] **Anisotropic radiation**. The assumption that the plasma is an isotropic radiator is employed as a mathematical approximation of the problem. This seems to be reasonable because of the observed reality in most of the cases – especially when two or more observers looking from different directions see the same plasma ball – but certainly not in all of them. In fact the possibility of a "beamed radiation" that occasionally overlaps with and/or replaces an isotropic radiating behaviour, cannot be in principle excluded.

[4] **Spectroscopic observation of a magnetized plasma**. A possible magnetic field of a plasma sphere can be measured using reasonably high-resolution optical spectroscopy, as the magnetic field is able to produce the so called *Zeeman Effect*, which consists in the splitting of each of the present spectral lines into several symmetric components around the position where each spectral line should be. The more the wavelength extent of such a splitting – quantitatively measured by a factor $\Delta\lambda$ (where λ is the wavelength) – the higher is the magnetic field intensity (Sobelman, 1980). This fact is very important observationally because it allows us to measure the magnetic field intensity directly from

sphere that, as it is extremely probable, contains its own magnetic field with its own pressure. If the sphere collapses for some reason the law of conservation of magnetic flux says that when the radius of the sphere is diminished the magnetic flux $\Phi = \boldsymbol{B} \cdot \boldsymbol{r}^{-2}$ is conserved, while the magnetic field intensity $\boldsymbol{B}$ increases as the square of the radius $\boldsymbol{r}$ of the sphere. Clearly while this happens the law of angular momentum conservation given by $\boldsymbol{\Omega} = \boldsymbol{m} \cdot \boldsymbol{\omega} \cdot \boldsymbol{r}$ (where $\boldsymbol{m}$ is the mass of ionic and electronic particles and $\boldsymbol{\omega}$ its angular velocity) shows that if the radius of the sphere diminishes and the mass remains constant and if the plasma ball is subject to some spinning motion, the angular velocity increases. This means that when a plasma sphere collapses for some reason the plasma particles start to rotate faster and the magnetic field that is frozen inside it is amplified: this might be an example of magnetized plasma toroid in fast rotation (Seward et al., 2001). Clearly the increased amplitude of the pressure components (mechanical and magnetic) and of the gas density inside the plasma increase its temperature (due to the law of perfect gases) and consequently also its luminosity, so that we have a highly energetic plasma sphere that is suspiciously existing in a totally isothermal condition (constant temperature without adiabatic cooling via expansion), as it is effectively noticed by observations. Conclusively, a work hypothesis is ventured in which the possible collapse of a plasma ball is able to increase its temperature and that a single plasma ball might shift from a temperature regime to another, where anyway temperature is always maintained constant at any given regime. In such a way, if such a hypothesis is correct concerning observed reality, high-temperature isothermal plasma balls should be accompanied with high values for magnetic field intensity and rotation rate.

Finally, we now return to the plasma sphere hypothesis since naturally produced plasma spheres may well produce beams of radiation. Witness reports do exist about this kind of manifestation. How can this happen? We have not yet a definitive answer, of course. But this possibility might be a stimulus to trigger the development of a valid physics concerning this too. First of all we should ask what is able to produce a beam in such a specific case. It is not unreasonable to suggest that one possible cause is a mechanism to accelerate particles, possibly produced when high-energy electrons are extracted from a high-temperature plasma by an enhanced magnetic field whose morphology turns from spherical to cylindrical when the plasma ball collapses and starts to rotate faster. This is also known in the macro-scales of astrophysics such as in the case of active galactic nuclei or similar objects such as Quasars. This is an example of high-energy relativistic particle acceleration along magneto-channelled tubes called “jets” (Melia, 2009). This also happens on a much smaller scale with non-stationary stars such as T Tauri, FU Orionis stars, pulsars, neutron stars and magnetars that are surrounded by an accretion disc made of nucleons. All of these objects (galactic and extragalactic) are known to emit synchrotron radiation, whose mechanism is due to the acceleration of electrons and/or protons at relativistic velocities through a very strong “magnetic tube” that collimates them. An even smaller scale is just a particle accelerator normally used in our subnuclear laboratories, where particles are confined, collimated and accelerated by a very powerful magnet of cylindrical shape. So, is a plasma sphere able to occasionally work as a particle accelerator? Possibly yes, if some openings do exist on the plasma confined aggregate. In the case of a sphere this might occur in the polar regions (orthogonal to the direction of the plasma rotation), where magnetic lines are opened. This configuration of a magnetosphere is expected to be the same at all scales, i.e., on Earth, in pulsars, and even larger structures. Why not also in plasma spheres that are occasionally seen inside our atmosphere? (see Fig. 13).

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optical spectroscopy: this measurement is absolute, regardless of the light source’s distance (differently from standard magnetometric measurements, which are strictly dependent on the distance of the source, where magnetic field intensity is expected to decrease exponentially with the distance of the source).

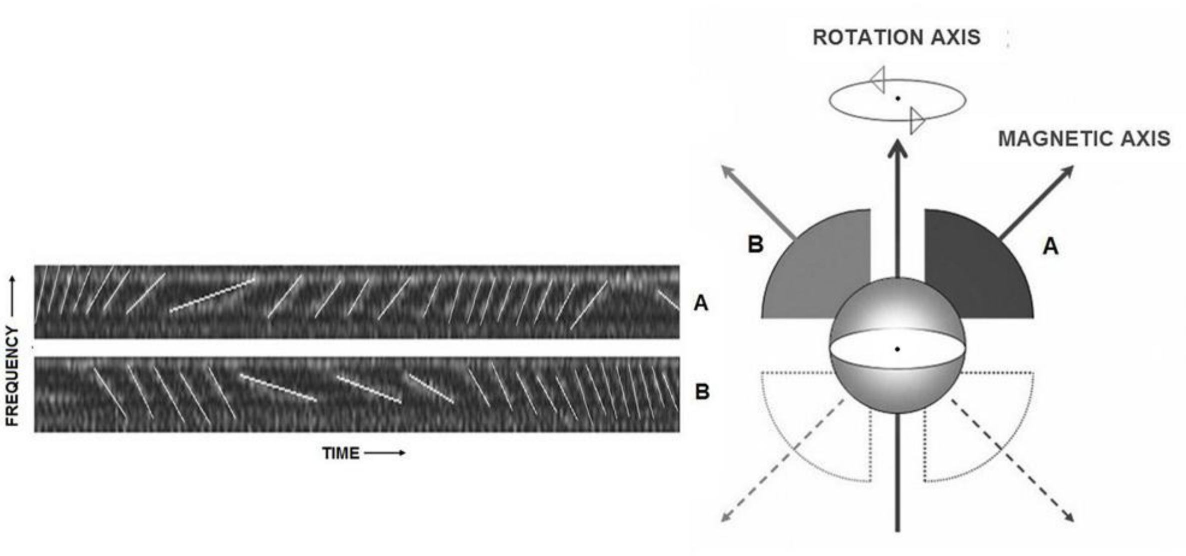

Figure 13. *Left*. Peculiar signals (enhanced here) shown by VLF spectrograms obtained in Hessdalen, July 2000, showing a periodic Doppler effect with inversion from blue to red shift (velocity $V = c \cdot (\Delta\nu / \nu)$, where c = light velocity and ν = frequency) and characterized by a velocity ranging from 10 to 100,000 Km/sec. A periodic Doppler effect is manifested by two configurations: 1) blue shift - indicated by A, where frequency increases with time; 2) red shift - indicated by B, where frequency decreases with time. *Right*. Physical qualitative model showing a fast spinning plasma sphere able to accelerate relativistic particles, where the beam periodically approaches (blue shift A) and recedes (red shift B) from the observer. The beam is emitted along the magnetic axis, which doesn't coincide with the rotation axis of the plasma sphere: this generates an "oblique rotator", which is the main cause of the Doppler Effect and its inversion from blue to red shift. A similar mechanism occurs in high-energy astronomic objects such as pulsars.

It is not possible to exclude that some kind of "self-regulating" mechanism is also able to "relax" the spherical symmetry into a cylindrical one (in a very similar fashion as in the case of particle accelerators), where the magnetic lines are possibly containing, collimating, confining and occasionally accelerating some of the particles that are inside it. We do not know yet how this symmetry change may occur in this kind of plasma concentrations, but we do know that observed light balls are often subject to shape change (Teodorani, 2004), including the one from spherical to cylindrical or other elongated shapes. This witnessed fact should make our neurons work. What we observe in nature is often stimulating and triggering our brain, especially if we then compare what we see (and occasionally measure) in this specific context with what we see and know about in the astrophysical environment. Nature should be "self-similar" from the micro to the macro scales, and this general law should help us to derive laws of physics everywhere[5], even where we shouldn't even expect it to, such as in the case of plasma light balls.

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[5] **New laws of physics?** Nature seems to be governed by similar laws when we pass from large to relatively small scales (not involving quantum effects). For instance, if we assume that an inner force (of whatever nature) is balanced by an external force such as pressure, an atmospheric plasma sphere of the Hessdalen-like kind can be potentially described by the same laws describing an object of stellar dimension. But we cannot exclude a priori that different physical laws that we do not yet know are sometimes operating at some specific scales. In fact, witnesses reported several peculiar behaviours of plasma spheres that cannot be easily explained using conventional physics. As an example of these peculiarities, according to several witnesses plasma spheres when appearing together at the same time but at different positions seem to behave following a sort of "synchronism" as if they all had a unique system driving them (Devereux, website). This behaviour strongly reminds us of one encountered in much smaller scales such as atomic or sub-atomic particles, where quantum laws, and more specifically, the mechanism of "quantum entanglement", entirely govern their system. This is a still unexplored forest for our knowledge in physics, for which a "macro-quantum" behaviour (Teodorani, 2007b; 2008) is not yet accepted by the mainstream scientific community.

Let's now briefly resume the physical concepts that have been discussed in detail in this section:

- In principle a "light ball" is expected to be the result of an harmonic equilibrium between one inward force of still unknown origin and an outward force represented by the pressure of naturally expanding ionized gases.
- Observations showed so far that, when light phenomena are in sight, such a force equilibrium is perfect as temperature is constant during all the time when it is observed (anyway this doesn't mean at all that temperature cannot change and that new "temperature constancy" regimes are settled in further phases).
- Mathematical modelling using a set of equations derived from the original equations of stellar structure can be used in this case too, apart from some constants and exponents that depend on the specific nature of the inward central force whose nature is not known yet. If all the parameters are known we are in such a way in a condition to derive the spatial structure of a single light ball.
- Only observational data can drive theoretical modelling. Therefore a full theoretical analysis of the problem can be carried out only when observed geometric and physical quantities are opportunely related to intrinsic quantities once the distance factor is known with the necessary precision.
- The modelling physics applied to a single sphere must be extended to a cluster of spheres, so that a quantity called "integrated luminosity" becomes the most important observed parameter and the said modelling includes simultaneously N plasma balls simultaneously. In such a way we are in a potential condition to derive the spatial structure of a light ball cluster.
- The single components of a cluster might be connected together by electrostatic forces but without any thermal energy transfer from the one to the other. Therefore an additional physical model should be elaborated in order to describe quantitatively such a collective interaction.
- According to observations, the appearance and the disappearance of new spheres inside a cluster is, so far, believed to be the main cause of the time-variation and/or pulsation of "integrated luminosity". Studying this variability means studying the time-dynamics of a light-ball cluster. This includes not only irregular or regular variability such as pulsation effects, but also a possible occasional increase and/or decrease of the pulsation period.
- A light ball can be determinant in exciting or ionizing the surrounding atmospheric medium, in the same way in which an astrophysical nebula brightens. This can be opportunely modelled using known techniques.
- The balance of forces that keeps united the plasma inside a single "light sphere" may not depend only on thermal quantities, but also on magnetic and rotational ones, whose presence or absence might determine a substantial increase or decrease of the values of fundamental parameters such as pressure, density and temperature. Therefore the simplified thermal problem might be matched with the physics of magnetism and of gas rotation, complicating the mathematical problem but rendering the treatment of the problem ontologically more realistic and complete.
- Plasma light balls might be the source of the acceleration of high-energy particles, by working as magneto-channelled means through which particles may be ejected, in a similar fashion as the one currently observed on much larger scales in some astrophysical objects such as active galactic nuclei, pulsars or magnetars. There might be a "self-similar" signature in nature, where certain physical processes are occasionally replicated at smaller scales.

All of these work hypotheses can be tested after appropriate measurements are done.

5 – Methodology of research

Research on this kind of anomalies of nature is quite difficult to carry out due to several reasons. Though being recurrently seen in specific areas of the world, the time of apparition of the targets of this research is not predictable at all. Therefore, only long-lasting explorative missions on the field can offer the possibility to acquire high-quality and redundant data. Of course automated video camera systems (Marfa Lights Research, website; Strand, website; SOSO Live Camera, website; LTPA Observer Project, website) are able to record a lot of events during a long time without any need of man's presence. Nevertheless this kind of data can be scientifically useful mostly for statistical studies (Teodorani, 2004; Teodorani & Strand, 2001), to study occasionally the kinematical aspects of the light phenomenon and, in case, to establish time-correlations with electromagnetic data if at the same time EM and/or magnetometric instrumentation is automatically in function. But these data are not able, so far, to furnish information of more analytic scientific relevance such as the ones obtained using optical spectroscopy and/or operations using Lasers and Lidars (Teodorani, 2001; Strand, 1984), which are allowed only if expert personnel are present on the field with reasonable constancy. It is quite clear that all this requires a lot of money funding for research, which so far seriously lacked. And this is quite strange because such a phenomenology, showing often the manifestation of a high energy level and of mysteriously "self-contained" structures, should stimulate someone to encourage this investigation, which might furnish in the future a way to brindle this kind of energy for human use.

We now have only a preliminary scientific picture of the phenomenon. But we do not have yet any definitive and clear explanation of the enigma of the self-containment of such light balls, if they can be effectively considered plasma objects. Apart from the possible geophysical and/or atmospheric triggering causes of such phenomena (Bunnell, 2003; Freund, 2003; Teodorani, 2008) for which reasonable correlations can be found, and from remarkable work hypotheses on their intrinsic physical nature, the physical mechanism that makes so that these phenomena have the shape and the dynamical behaviour they manifest is almost unknown so far. The problem here is quite similar to what occurs with the ball lightning phenomenon, to which "earthlights" might be related in some way. Of course the only way to solve the still open physical problems in this field is to have the possibility to carry out a systematic and very well funded research, so that recurrence areas can be monitored constantly using both scientific personnel on field and automatic measurement equipment (Teodorani, 2001; Teodorani & Strand, 1998). We should now point out what the methodological philosophy of this research should be. This can be done through very specific points that are discussed here:

1. *Distinguishing the signal from the noise* – Many of the luminous phenomena that have been reported and studied so far tend to occur very close to the ground (see Fig. 10). This may create very often a lot of confusion between real anomalies and light manifestations that can be explained prosaically. For instance, car headlights, cottage lights, streetlights, flashlights, fire camps and several other sources of manmade origin can be mistaken for true "earthlights" by observers who are not used to reason carefully on what they have around and who, only too often, let themselves be dragged by autosuggestion, excessive emotional state and even delusional sickness (Teodorani, 2008; 2009a; 2009c). Conversely, gratuitously "sceptical" scholars having no knowledge and/or experience on the physical phenomenon under study, tend to dismiss true anomalies as prosaic facts basing their considerations on superficiality and unrealistic forcing (Adams, 2007; Teodorani, 2007a). All this said, it is also necessary to acknowledge that, in addition to simple misinterpretation of quite well known light sources and known astronomical objects

(UAPRS, website), insidious situations in nature may also occur when the light of a car, for instance, can be drastically altered and/or amplified by several effects such as Fata Morgana, mirage, reflecting soil and even diffraction effects when a car headlight is seen through trees that are seen far away from the observer (Pettigrew, 2003; Teodorani, 2005; 2008). Sometimes nature can produce quite deceiving effects that can be of serious obstacle to scientific research on the earthlight phenomenology. This is the reason why before carrying out an explorative mission to a specific area a good knowledge of the inhabited territory must very well possessed in all details. The same reasoning is valid for airplane lights: it is quite well known that landing or turning airplanes can produce apparently strange light effects (such as light amplification, sudden appearance or disappearance, for instance), which are totally explainable indeed (IEA, website; Teodorani, 2008; 2009b). This is more than a good reason for any observer to check all the flights over the area he/she investigates. Another insidious situation can be created when some well-known luminous planets, such as Venus or Jupiter, is just rising low on the horizon: in some occasions it can appear just a bit above the top of a hill or a mountain giving to inexpert observers the illusion to have seen a "light ball". This can be easily checked by consulting a very simple digital planetarium, which can furnish the position and the brightness level of any known celestial object at every date and time (Teodorani, 2005; 2009a). Another efficacious way to rule out or confirm prosaic lights is to take an optical spectrum of them. If, for instance, an apparently strange and flickering light is seen over the top of a mountain this doesn't mean necessarily that it is an earthlight floating low in the sky. Most often this is a streetlight or cottage light that is located on a mountain behind that is not visible in the darkness or hidden by fog: this can be confirmed very easily and quickly after taking an optical spectrum of that light. If the spectrum shows the typical lines of Mercury or Sodium this is a confirmation that the observer is seeing a streetlight (Teodorani, 2010a). If the spectrum shows to be a continuum (without lines and/or monochromatic features in it) and if the light is slowly moving and occasionally changing intensity and speed, that can be more probably a car turning on a little road hidden somewhere in the bush (Teodorani, 2007a). All these are typical sources of "noise polluting the signal" that we are searching for, in order to fix them once and for all in order not to invalidate our data. These considerations demonstrate that this investigation demands great carefulness and precision in order not to mistake the real target of research and lose an amount of time and energy for nothing. This is an extremely important topic for the methodology with which specific research on earthlights must be carried out.

2. *Research strategy* – Using scientific instrumentation doesn't necessarily mean to do science effectively. People who use these devices (even knowing their functioning very well) must be fully conscious of what they are searching for; on the contrary the numbers that come out from measurements are senseless and a time loss. Of course, in addition to a systematic and methodical monitoring of a specific area, "work hypotheses" on the possible nature of light phenomena (including possible prosaic causes of them) must be elaborated in order to prove or confute them once objective crucial instrumental measurements are taken. Of course physicists or, in case, particularly well prepared scientists of other branches and engineers are the most expert in this approach. Healthy (and not dogmatic) scepticism bust be always strictly joined with a healthy open minded approach as well: we do not know all of Nature, and sometimes reality might even surpass our fantasy (Teodorani, 2007b; 2008). What counts here is not the theory that is in case constructed to explain a certain anomaly, but its internal coherence, its match with observed/measured facts, and, possibly, its potentiality in offering the opportunity to reproduce phenomena at will under laboratory control (Freund, 2003; Teodorani & Strand, 1998). To conclude this topic, science is an eminently critical work that evolves through subsequent

approximations and not a parade of dogmas or a pure show of instruments. Sometimes it is much more important to use properly simple but well-working, fully portable and efficient scientific instruments than using very sophisticated or complex ones without adopting any strategy or being those instruments wholly useless to the main goal of this research (Teodorani, 2009c).

3. *Research tactics* – What we are investigating is something that is suspected to emit radiation at several wavelengths, simultaneously or sequentially. Therefore, only a simultaneous measurement session using several sensors that are sensible to different wavelength ranges must be carried out, in order to explore the real and most complete behaviour of such phenomenon (Teodorani, 2001; 2009c; see Fig. 14; see Table 2). This approach can be only done dynamically and not statically (for instance a simple photo or video taken alone tells almost nothing scientifically). It is in fact expected – as it is also often observed and reported – that we are not dealing with an unchangeable light phenomenon such as a streetlight is, for instance, but with a highly variable phenomenon, able, in the optical range, to pulsate its light, to appear and to disappear. Of course we cannot confirm that the phenomenon per se has really disappeared if we do not check, at the time of disappearance, the other wavelength ranges such as VLF-ELF, microwave or the medium infrared, for instance. Only a simultaneous measurement at different wavelength windows can tell us something concrete on the way in which the phenomenon works, as it might very probably consist in something that is much more variegated than what our eyes normally see. Redundant measurements of this kind, coupled with a careful check of where and when exactly the phenomenon appears – just in terms of atmospheric conditions and geophysical characteristics of the area – can allow researchers to obtain information on a probably repeatable, and consequently numerically simulable, physical behaviour. This philosophy of research is exactly the same that is currently used in astrophysics, especially when variable celestial objects (such as pulsating stars or quasars) are studied (Lang, 1998; Teodorani, 2001). The dynamical processes that are understood in such a way allow us to construct a real physical model that is strictly based on the data that are acquired through the observation process. It is in this way, for instance, that astronomers understood the mechanism that makes a star, such as a Cepheid, pulsate. Of course the reality of facts in the field is not as simple and predictable as when one works from an astronomic observatory. In addition to the moments in which the phenomenon is not present and the instruments record nothing, it more normally happens that only a few instruments are effectively used all together due to reasons of limited funding or personnel and of a too short duration of instrumental monitoring sessions (Teodorani, 2009c; see Table 1). But it is a concrete fact that a more systematic approach can be realized in the course of instrumented expeditions only if these researches are properly funded and not only left in the hands of a few willing scientists and/or experts working on this subject in their free time. Nevertheless this voluntary research work has permitted to find something that might have scorched the surface of what these phenomena really are. In such a way it is inevitable that work hypotheses are ventured, just after observing preliminary data. These work hypotheses are of vital importance because they function as a guide for researchers: not in order to demonstrate forcefully a theory of which someone is in love, but as a "testing probe" of what is outside: this inevitably recalls more measurements and helps us to understand more clearly what we really need in order to solve some enigmas. Of course theories and hypotheses can be confirmed as well as confuted: but in this way science goes forewords in its own dialectic path. Moreover, it is important to take more theories into account and not only one, and study all of them carefully (Bunnell, 2003; Freund, 2003; Fryberger, 1997; Teodorani & Strand, 1998; Turner, 2003). Many of these theories might contain something that is near the effective truth; therefore they must be examined with much attention. Certainly the only way to trigger an intellectual dynamics in this specific research is to

follow a very rigorous scientific protocol, as the one introduced in the previous topics. This means not only a logical treatment of a few acquired data, but the same applied to all the possible data that can be effectively acquired in this specific case. Of course in order to drive this tactics to the construction of a real and complete physical science we need many instruments of different kinds to be used all together (possibly) at the same time both when the light phenomenon is in sight and when it is not. The most essential instruments that should be used are presented in Table 2.

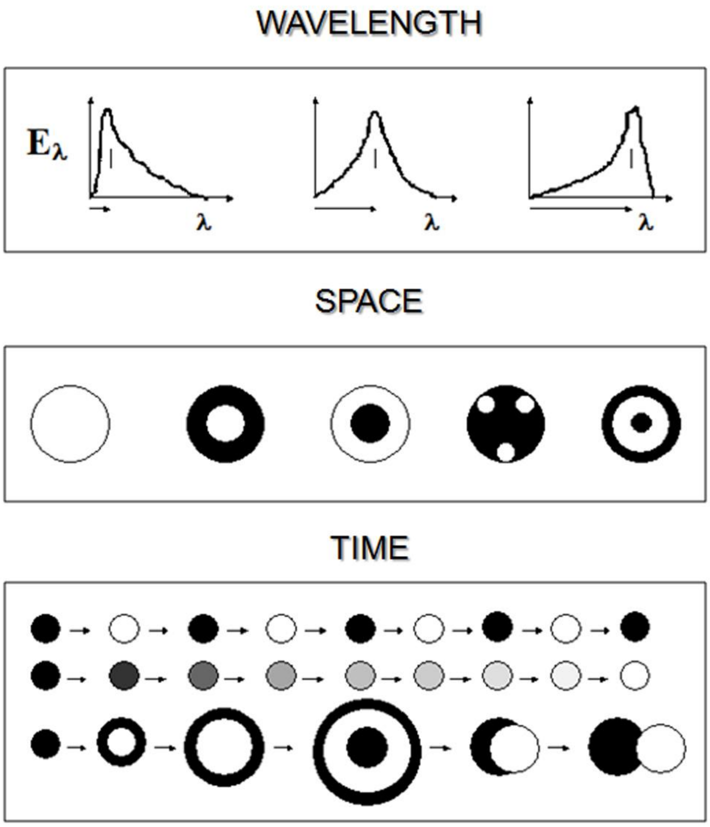


Figure 14. Tactics of earthlight research in three parallel steps: a) the behaviour of the phenomenon at different simultaneous wavelengths; b) the way in which radiated power is distributed over a surface at any given time; c) the way in which the phenomenon changes its luminosity with time.

4. *The importance of the Distance parameter* – Variability studies of the light phenomenon carried out over a wide wavelength spectrum can furnish important information on the physics of the problem from the dynamical point of view. But if we do not know the distance of the light phenomenon, we cannot derive its intrinsic energy density and its effective spectral energy distribution at any given time, as what we measure is only the “apparent emitted power” of an energy source having an intrinsic power (at all wavelengths) that diminishes exponentially as the inverse of the distance squared: this is the law of electromagnetism that characterizes all radiating phenomena in the Universe. Apart from a few valuable exceptions, such as the possibility to derive the intrinsic magnetic field intensity of a light ball through optical spectroscopy without any need to know the distance of the light source (Teodorani, 2001; 2009c), more generally, without a knowledge of the light phenomenon’s distance we can do only a very limited and “symptomatic” physics. If we really want to understand what is a “light ball” we necessarily need to put all of our reference systems at zero distance from the ball. That’s the reason why measurement sessions using the appropriate sensors must be simultaneously accompanied by the determination of the source’s distance. This can be done in several ways or even redundantly (if the local conditions are able to permit this): the use of radars, Laser range finders, stereo photography, triangulation or even comparisons with the dimensions of known objects (such as trees, for instance) to which a light ball is demonstrably close to, can, in principle, furnish the distance of the light balls that are

seen. In the analysis phase the coupling of distance determination with physical parameters obtained using several electromagnetic sensors can allow us to obtain the intrinsic EM power together with the intrinsic area of a light ball, once apparent EM physical values and angular diameter are determined directly during a measurement session. This is the necessary goal to reach if we really want to transplant this research into our laboratories in order to reproduce and/or physically simulate the phenomenon using computer codes. Only if we'll be able to do this research will enter in full title inside the field of fundamental physics. Otherwise it remains only in the realm of "fringe and partial physics" (even if certainly not pseudoscience, which is something totally different).

TABLE. 2 – Scientific information obtained using complete portable measurement equipment

SCIENTIFIC INFORMATION	**USED INSTRUMENTS**
support to target sighting	night goggles, image intensifier
target position	radar, theodolite, datascope
target tracking	radar, CCD camera
target recognition, identification	radio scanner, spectroradiometer
kinematical characteristics, regime of motion	videocamera, radar, thermocamera, weather station
distance, absolute luminosity, light surface distribution	Laser range finder, radar, triangulation, telescope, CCD camera, digital reflex camera, videocamera, thermocamera, weather station
temperature, pressure, density, chemical composition	telescope, digital reflex camera, CCD camera, thermocamera, microwave spectrometer, dispersion grating
magnetic field intensity	digital magnetometer, VLF-ELF spectrometer
electric and electrostatic fields	voltmeter, natural EM meter, electrostatic detector
electromagnetic emission: optical, infrared, ultraviolet, microwave, VLF-ELF	telescope, digital reflex camera, multi-filter CCD camera, thermocamera, ultraviolet detector, microwave and VLF-ELF spectrometers,
sounds and ultrasounds	VLF-ELF receiver, ultrasound detector
radioactivity	alpha, beta, gamma particles detector
reaction to laser light	300-600 mW green Laser, weather station
monitoring of specific areas	permanent automatic stations equipped with CCD camera, magnetometer, VLF-ELF spectrometer, radar
time variability	all the instruments
observational data analysis	specialized scientific software
statistical analysis of selected witness databases	data acquisition and inquiry from serious ufologists, computer data processing
physical modelling	specialized scientific software

5. *The importance of knowing the atmospheric and geophysical boundary conditions* – The light phenomenon under study is reported recurrently in specific areas of the world, some of which is quite close to fault lines and/or characterized by very particular composition of the soil (Devereux, website; Straser, 2007; 2009; Teodorani, 2008). In particular, the presence of quartz, iron, copper, hematite, when subject to tectonic stresses of several kinds (such as seismic or simple dilation/compression of rocks from daytime to nightime due to temperature differences, for instance) may trigger piezoelectric or similar effects that are able to produce sufficient voltage to trigger the formation of plasmoid forms in the low atmosphere. Piezoelectricity, triboluminescence, and P-holes (Freund, 2003) are currently believed to be one of the most

important causes for the formation of anomalous light phenomena. This is a more than valid reason to study such light anomalies not only as objects per se but also as phenomena that are possibly produced at a first phase by specific characteristics of the territory. This means that the physics of light phenomena must be strictly studied in connection with parallel geological and geophysical surveys (Straser, 2007; 2009). Knowing the triggering cause of these phenomena may also help to understand the physics of light phenomena themselves. Moreover, once the geophysical and geological causes of the formation of light phenomena are fully understood, it is potentially possible to identify new areas of the world, whose soil characteristics are well known, where (apparently unreported) light phenomena may occur recurrently. At the same time a possible atmospheric/ionospheric factor in creating light phenomena must be studied as well, both as a separate aspect and as an interacting factor with the specific local geophysical aspect. What's more, a full knowledge of the allegedly typical characteristics of low-height atmospheric conditions, such as temperature inversions, occurrence of mirages and/or other atmospheric refraction effects may help researchers to identify possible causes of the formation of "light effects" resulting only as a form of refraction of known manmade light sources (Pettigrew, 2003). The same can be said for the specific geological aspect, when, for instance, the soil, due to the minerals constituting the surface, presents characteristics of high reflectivity and, in case, also of particular concavity able to work as a lens able to focus light sources of known manmade nature (Teodorani, 2008). The "space weather" should be checked as well all the time, together with its possible interaction with the local atmosphere. Cosmic rays, particularly during active phases of the sun, may in principle work as a possible ionizing factor, which must be carefully taken into due account (Teodorani & Strand, 1998; 2001). And finally, peculiar planetary geometric configurations must be controlled when they may be a triggering cause of seismic events at particular areas of Earth (Straser, 2008), due not to gravitational effects that are totally negligible but rather to "resonance effects" that so far have not been sufficiently considered in depth. These ones might be another possible indirect cause of the triggering of light phenomena. Finally, only apparently "heretic" ideas such as the one called "electric universe theory" (Peratt, 2000) should be examined more in depth: electric effects in the interplanetary environment are not well known and the possible existence of electric charges in space has been too superficially dismissed by current astronomical theories. Of course electric effects in space may have an effect directly on our planet too, in some areas of which this effect may appear in enhanced form also possibly producing luminous plasmoids in the atmosphere. So we see that the study of anomalous light phenomena cannot be studied alone as physical objects per se, but rather as a physical phenomenology that must be inserted into a wider context, where geology, geophysics, meteorology, atmospheric physics, space and solar physics may play a quite important role. These interdisciplinary aspects should be studied all together as the cause of the formation of anomalous light phenomena might be the result of an interplay of many of these physical factors. This obviously means that a strict collaboration of scientists of several disciplines should be built up on a stable basis. Finally, a specific aspect of importance may be represented by the behaviour of plasmas in particular conditions, especially when they interact with very fine dust grains in our atmosphere (aerosol might be a potential example of this). Quite recent researches (Tsytovich et al., 2007) show that, once such an interaction is established, such grains may acquire an electric charge by sucking electrons from the plasma surrounding them, so that they may form a nucleus of electrons that in their turn are able to attract positively charged ions that belongs to the plasma itself: this mechanism can create the so called "plasma crystals". The most stunning aspect of such recent discoveries is that plasma crystals tend to create sort of helical shapes that are absolutely similar to the DNA in biochemistry: strong similarity is noticed both in the helical shape and in the characteristics of multiplication and replication of plasma crystals. Is Life a biological process based only on the chemistry of Carbon, or can it be created, in particular conditions, also by a purely physical process where plasma (a highly "cooperating structure" per se) interacts with fine dust grains? These discoveries might be well applied to study the behaviour of Hessdalen-like plasma forms, which in several occasions, in addition to producing occasionally spiral tracks (Strand, 1984), effectively tend to show a sort of self-replication process (Teodorani, 2004; 2008). This aspect of research, which is based not on speculations, but rather on experimental/simulation quantitative studies, should be soon extended to the physics of anomalous light phenomena with a main work-hypothesis in mind to be accurately tested: are "balls of light" a Life form? This hypothesis should be examined more deeply and experiments/observations aimed at proving or confuting this in the specific case of light phenomena should be accurately prepared.

6. *Appropriate partitioning of competences* – As we have already seen, this research demands necessarily a fully interdisciplinary approach. This means that scientists of different orientations should work together and not that one scientist or engineer, in addition to the one for which is fully competent, does also a work for which is not specifically competent. Knowing several aspects of research doesn't necessarily mean that all of those aspects can be effectively done all together by single individuals who own only specific specializations. For instance, acquiring a VLF spectrogram or an optical spectrum is an operation that can be done also by opportunely trained scientists and/or engineers who are not specifically specialized in this field. Anyway, such a procedure may be successful as it may not be. Experts in a specific field know exactly how to proceed, as in some cases – such as optical spectroscopy – also the data acquisition phase requires a specific competence that a non-specialist in the field doesn't necessarily have (Teodorani, 2009c). For instance, if we want to obtain a spectrum using a dispersion grating that is really scientifically treatable we need to use long focal lengths for the optics; otherwise the resolution will be seriously compromised. Low resolution spectra are rarely of some scientific relevance and whatever analysis carried out on them may be just tentative in the best cases and wrong in most cases. This can obviously happen when one passes from the data acquisition phase to the data analysis one. If spectra are not taken in the appropriate way and if the procedures for analysis and physical interpretation are not fully correct, the physics that comes out may be consequently a deception of the real physics of the problem. Who studies (decent) spectra of these phenomena (which are normally very difficult to obtain due to the transient nature of anomalous light phenomena) must know fully before what is spectroscopy and how the spectrum of a physical object should be: this competence in general belongs to physicists, physical chemists, astronomers, astrophysicists and engineers of some specific branch, not to other scholars (whatever their preparation in their specific field). This is a very important issue for a correct interpretation of physical evidence in the subject under study. In order to increase efficiency and effectiveness in these procedures it is absolutely necessary that the researcher who operates occasionally in fields that do not belong to his/her specific competence, consults punctually with specialists in the field before publishing results containing a bit too hasty conclusions (Hauge, 2007). Optical spectroscopy is just one example, which must be obviously extended to VLF-ELF spectrometry, magnetometry, microwave physics, infrared, radar and other techniques that are relevant to this research. Conversely, physical scientists who are not specialized in the functioning of some instruments (except for the use of them for data acquisition and analysis) are expected to consult with engineers of the appropriate branch, before running to conclusions. In few words, in order to optimize the effectiveness of this research non-specialists must always advise with specialists of specific branches (scientific and/or technical), especially when the data analysis phase is carried out, and in some cases also when the data acquisition phase is undertaken.

So we see that the only real condition to obtain real and concrete results in this so interesting research on "earthlights" is to fulfil at least the six points that have been discussed here. Science is most of all a method, not a collection of notions to be manipulated arbitrarily according to the intuition of the moment. Of course intuition is extremely important (and elaborating some speculations too, in some cases), but it acquires a really high valence only when it is explicated through the rational/experimental method, which must always bring to a quantitative outcome. Nobody is God and, except for scientific intuitions by single researchers that might be really basic for the research conduct, it is inevitable that the (different) technical competence of many must converge towards a common goal: substantially this means that only team work can bring to concrete and definitive results. Of course this is not always possible, especially when money funding and a concrete scientific infrastructure and organization are lacking (as it happens normally in this specific research). But it remains that the academic approach to scientific problems of whatever nature, including earthlights, is the only one that can bring to the production of real results. Conversely, a rigid academic behaviour, wayward to new possible physical realities and to true innovation, can bring necessarily to the stagnation of science, which belongs to mankind and not to a small ring similar to the "Pickwick circle". Open mind matched with healthy scepticism must always lead us in this research, where there is not space for emotionality but only for the enthusiasm and Teutonic determination in reaching the main goal.

Conclusions

The most appropriate conclusive remark that can be given here is probably the one that stresses the real main goal of this research, consisting in searching for the physical mechanism that keeps light balls so perfectly confined in a spherical shape and that makes them produce so much energy. Once we'll understand definitively this mechanism we'll have at our disposal the key to reproduce this energy – possibly a clean form of it – in a laboratory and consequently to use it for many mankind's needs, now compelling in this so critical period of our civilization. After all, quite recent laboratory experiments were able to reproduce for a short time lapse a ball lightning of small size (Muir, 2007). Why not thinking that we might replicate in a lab a much more energetic phenomenon such as a so called "earthlight"? Of course the use of this possible new energy source might be double-faced: a) tapping it under control conditions and peacefully in a similar manner as in electric or nuclear centrals; b) using this energy as a weapon system. The second possibility seems possible as well, or even easier (Teodorani, 2010b): after all, once the physical mechanism is known it might be possible to find out a way to liberate suddenly the energy contained inside a light ball by nullifying instantly the central force that permits a hydrostatic equilibrium with the outward pressure force. The implications of this are really weird. But, as we all know, the use of some science or technology depends mostly on the nature of man. The main wish is that mankind becomes more peaceful and mature, so that an "infinite possibility" might be managed only for the common well.

References

1. 45° G.R.U. : http://www.45gru.it/STRUTTURA.htm
2. Adams, M. H. (2007). Characteristics of the August 7, 2002 Recurring Hesdalen Light Determined By Video and Triangulation. *IEA Articles* : http://www.earthlights.org/pdf/triangulation.pdf
3. Akers, D. – The Willard J. Vogel Study : http://www.vogelstudy.org/

4. Bunnell, J. (2003). *Night Orbs*. Ed. Lacey Publishing Company, USA.
5. CROSS Project (Gian Franco Lollino et al.): http://www.copernico-online.org/cross.asp
6. Devereux, P. – "Unidentified Atmospheric Phenomena – Seeing the Light". *Fortean Times* : http://www.forteantimes.com/features/articles/58/unidentified_atmospheric_phenomena.html
7. Freund, F. T. (2003) "Rocks that Crackle and Sparkle and Glow: Strange Pre-Earthquake Phenomena". *Journal of Scientific Exploration*, 17, no. 1, pp. 37-71 : http://www.scientificexploration.org/jse/articles/pdf/17.1_freund.pdf
8. Fryberger, D. (1997). A Model for Ball Lightning. *ØIH Rapport*, *1997(5),* Høgskolen i Østfold (Norway), pp. 1-82.
9. Haines, R. F. (2007). Small Light Ball Flies Near Airliner; Investigation of High Resolution, Digital, Color Photographs of July 3, 2005 at 2031 Hrs., Palo Alto, California. *NARCAP Technical Report,* N. 12 : http://www.narcap.org/reports/012/uap_photo_7-3-05_PaloAlto.pdf
10. Hauge, B. G. (2007). "Optical spectrum analysis of the Hessdalen phenomenon. Preliminary report June 2007". The 7th Biennial European Society for Scientific Exploration, Meeting, August 17-19, 2007 Røros, Norway. Strand, Erling P. (Editor), PROCEEDINGS, ISBN: 087-82-992639-1-7, pp. 31-42 : http://www.itacomm.net/ph/2007_HAUGE.pdf
11. Hiltner, W. A. (Ed.), & G. P. Kuiper & B. M. Middlehurst (Series Eds.). (1962) *Stars and Stellar Systems, Compendium of Astronomy and Astrophysics*. University of Chicago Press.
12. Hourcade, M. (2007) *OVNIs – La Agenda Secreta*. Ediciones Cruz del Sur (http://mitosdelmilenio.com.ar/mytovn12.htm)
13. "Il Mistero di Caronia", Tutto UFO – Uno Sguardo Verso il Cielo : http://shaika81italy.spaces.live.com/blog/cns!538A73FC85B17040!1407.entry
14. International Earthlight Alliance IEA (by Marsha Hancock Adams) : http://www.earthlights.org/index.html
15. Italian Committee for Project Hessdalen (ICPH): http://www.itacomm.net/PH/CIPH/HOME_PAGE.html
16. Kippenhahn, R. & Weigert, A. (1994) *Stellar Structure and Evolution*. Springer.
17. Lang, K. R. (1998), *Astrophysical Formulae: A Compendium for the Physicist and Astrophysicist*, 3rd ed., New York: Springer Verlag.
18. Limb Darkening, Wikipedia: http://en.wikipedia.org/wiki/Limb_darkening
19. Long, G. (1990) *Examining the Earthlight Theory: The Yakima Ufo Microcosm*. J. Allen Hynek Center for UFO Studies.
20. LTPA Observer Project : http://ltpaobserverproject.weebly.com/
21. Maccabee B. (1999), Optical power output of an unidentified high altitude light source, *Journal of Scientific Exploration*, 13, pp. 199-211.
22. Marfa Lights Research : http://www.nightorbs.net/index.html
23. Melia, F. (2009). *High-Energy Astrophysics*. Princeton University Press.
24. Montebugnoli, S.; Monari, J.; Cattani, A.; Maccaferri, A.; Poloni, M.; Bortolotti, C.; Roma, M.; Hauge, B. G.; Strand, E. P.; Cevolani, G. (2002). Measurements with a low power pulsed radar in the Hessdalen 2002 camp. *ICPH Articles* : http://www.itacomm.net/ph/radar/radar_e.pdf
25. Muir, H. (2007) "Lightning balls created in the lab". *NewScientist.com* : http://www.newscientist.com/article/mg19325863.500-lightning-balls-created-in-the-lab.html
26. National Aviation Reporting Center on Anomalous Phenomena (NARCAP) : http://www.narcap.org/
27. Orbwatch : http://www.globalserve.net/~mallet/
28. Ohtsuki, Y. H. & Ofuruton, H. (1991). Plasma fireballs formed by microwave interference in air. *Nature*, 350, pp. 139 – 141.
29. Peratt, A. L. (2000). *Plasma Universe: Beyond the Big Bang*. St. Martin's Press.
30. Pettigrew, J. D. (2003) "The Min Min light and the Fata Morgana - An optical account of a mysterious Australian phenomenon". *Clinical and Experimental Optometry*, 86: 2: 109–120 : http://www.uq.edu.au/nuq/jack/MinMinCEO.pdf
31. Progetto M.A.L.D.A. (Nicola Tosi) : http://www.ansu.it/Rubriche/Malda/Indice.html
32. Project Hessdalen : http://www.hessdalen.org/
33. Project UAP Italia : http://www.projectuap-italia.org/
34. Rutledge, H. (1981) *Project Identification: The first Scientific Study of UFO Phenomena*. Prentice-Hall.
35. Sassalbo Project (Marco Peruzzi, Iacopo Nicolosi et al.) : http://www.sassalboproject.com/link.php?m=8
36. Seward, C., Chen, C. & Ware, K. (2001). Ball lightning explained as a stable plasma toroid". *Pulsed Power Plasma Science*, Vol. 1, pp. 269-272.
37. Smirnov, B.M. (1994). Long-lived glowing phenomena in the atmosphere, *Physics-Uspekhj*, *37*(5), p. 517.
38. Sobelman, I. I. (1980). *Excitation of Atoms and Broadening of Spectral Lines*. Springer & Verlag.

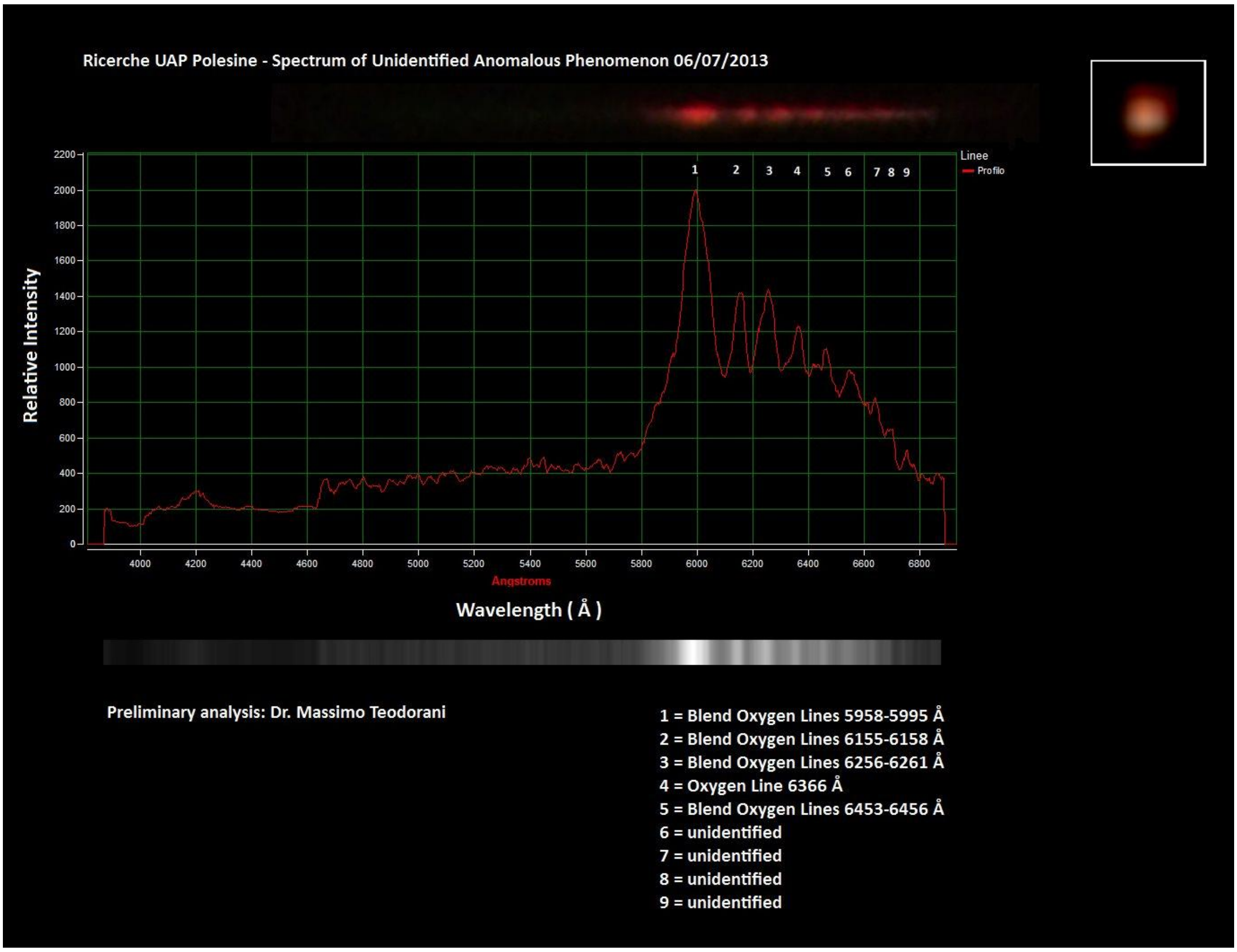
39. SOSO Live Camera (Massimo Silvestri et al.) : http://www.ciph-soso.net/SOSO/SOSO_LIVE_CAMERA.html
40. Stenhoff, (1999). *Ball lightning. An unsolved problem in atmospheric physics.* New York: Kluwer Academic/Plenum.
41. Stephan, K. D.; Ghimire, S.; Stapleton,W. A.; & Bunnell J. (2009). Spectroscopy applied to observations of terrestrial light sources of uncertain origin. *American Journal of Physics*, 77(8), pp. 697-703 : http://uweb.txstate.edu/~ks22/pdfs/MLPaper_AJP.pdf
42. Strand, E. P. (1984). Project Hessdalen 1984 – Final Technical Report. *Project Hessdalen – Articles and Reports* : http://www.hessdalen.org/reports/hpreport84.shtml
43. Strand, E. P. (1996). "Min-min light" i Australia. HØit, Nr. 2-96 : http://www.it.hiof.no/prosjekter/hoit/html/nr2_96/erling_i_australia.html
44. Straser, V. (2007). Precursory luminous phenomena used for earthquake prediction. The Taro Valley, North-western Apennines, Italy. *New Concepts in Global Tectonics Newsletter*, n. 44, p. 17-31.
45. Straser, V. (2008). Planetary perturbations and "twin earthquakes": a model for the long-term prediction of earthquakes. *New Concepts in Global Tectonics Newsletter*, n. 46, p. 35-51.
46. Straser, V. (2009). Luminous Phenomena in the Atmosphere: Signs of Uplift of the Earth's Crust? *New Concepts in Global Tectonics Newsletter*, n. 53, p. 47-56.
47. Teodorani, M. & Strand, E.P. (1998). Experimental methods for studying the Hessdalen phenomenon in the light of the proposed theories: a comparative overview. *ØIH Rapport*, n. 1998:5, Høgskolen i Østfold (Norway), pp. 1-93.
48. Teodorani, M. (2001). Physics from UFO Data. *ICPH Articles*, N. 2 : http://www.itacomm.net/ph/phdata_e.pdf
49. Teodorani, M. & Strand, E.P. (2001). Data Analysis of Anomalous Luminous Phenomena in Hessdalen". *ICPH Articles*, n. 3 : http://www.itacomm.net/ph/hess_e.pdf
50. Teodorani, M. (2004). A Long-Term Scientific Survey of the Hessdalen Phenomenon. *Journal of Scientific Exploration*, Vol. 18, n. 2, pp. 217-251 : http://www.scientificexploration.org/jse/articles/pdf/18.2_teodorani.pdf
51. Teodorani, M. & Nobili, G. (2004). "Monitoraggio di Anomalie nell'area di Solignano". *Galileo* (sezione: "Ricerche") : http://www.galileoparma.it/Solignano_Report_1.pdf
52. Teodorani, M. (2005). IEA 2003 Report: Optical Investigation of Anomalous Light Phenomena in the Arizona Desert. *IEA Articles* : http://www.earthlights.org/pdf/massimo.pdf
53. Teodorani, M. (2007a). Hessdalen-Lichtphänomene und die Inkonsistenzen der Autoscheinwerfer-Deutung. *Zeitschrift für Anomalistik*. Fortgesetzte Diskussionen. Band 7 (2007), Nr. 3, pp. 286-299. / Version in English: Hessdalen Light Phenomena and the Inconsistency of the "Car-Headlight" Interpretation, *Scienza e Mistero* (2007): *http://www.scienzaemistero.com/2007/pdf/Anomalistik_Teodorani.pdf*
54. Teodorani, M. (2007b). *Entanglement*. MACRO Edizioni.
55. Teodorani, M. (2008). *Sfere di Luce*. MACRO Edizioni.
56. Teodorani, M. (2009a). "Need to Know vs. Need to Believe in Ufology", *U.A.P.S.G. Articles*: http://www.uapsg.org/2009/09/paper-to-think-about.html
57. Teodorani, M. (2009b). A Comparative Analytical and Observational Study of North American Databases on Unidentified Aerial Phenomena. *NARCAP Technical Reports*: http://www.narcap.org/reports/CompAnal/ONNYCT_Paper_MT_2009_REVISED.pdf
58. Teodorani, M. (2009c). Scientific Inquiry on Anomalous Atmospheric Light Phenomena: Past Research Gaps and New Methodological Goals. *ICPH Articles* : http://www.itacomm.net/PH/2009_Teodorani.pdf
59. Teodorani, M. (2010a). "Aerial light anomaly reported in Avalon Beach – Updated Report 2010" *Northern Beaches Sightings*: http://www.surfin.com.au/nbsightings.html (*Avalon Rectification Document ON NORTHERN BEACHES LIGHT ACTIVITY*)
60. Teodorani M. (2010b). Spherical Unidentified Anomalous Phenomena: Scientific Observations and Physical Hypotheses, Danger Evaluation For Aviation and Future Observational Plans. In monograph *Project Sphere* edited by R. H. Haines – NARCAP : http://www.narcap.org/Projsphere/narcap_ProjSph_2.4_MaxTeo.pdf
61. Tsytovich, V.N.; Morfill, G. E.; Fortov, V. E.; Gusein-Zade, N. G.; Klumov. B. A. & Vladimirov, S. V. (2007). From plasma crystals and helical structures towards inorganic living matter. *New Journal of Physics*, 9, p. 263 : http://www.iop.org/EJ/article/1367-2630/9/8/263/njp7_8_263.html
62. Turner, D. J. (2003). The missing science of ball lightning. *Journal of Scientific Exploration,* 17, n. 3, pp. 435-496.
63. Unidentified Aerospace Phenomena Reporting Scheme (UAPRS) : http://www.uapreporting.org/
64. Warren, J. P. (2004). "Report on the Cause of the Mysterious Brown Mountain Lights". *LEMUR* : http://shadowboxent.brinkster.net/brownplasma.html
65. Zou You-Suo (1995). Some Physical Considerations for Unusual Atmospheric Lights Observed in Norway. *Physica Scripta*, 52, pp. 726-730.

ADDENDUM – Updates 2014

A. Identification of spectral lines in the spectrum of an anomalous light phenomenon

An astro-amateur group named “UAP Polesine”, lead by Mr. Jerry Ercolini, was able to obtain the spectrum of an anomalous light phenomenon in the area of Polesine (region Veneto, north-east Italy). Since some years that area is characterized by the recurrence of unexplained nocturnal lights. This group always sends their reports to me. A few months ago they were finally able to obtain an optical spectrum of such phenomena, using a DSLR camera and a dispersion grating. After analyzing the spectrum, I was able to identify Oxygen lines. This is extremely important as this is a proof that really something unknown is exciting and ionizing our atmosphere. The analysis work is now in progress. But it is possible to show preliminary results in the figure below.

Of course all this shows the importance of optical spectroscopy in this investigation, as it allows to distinguish prosaic cases (such as manmade illumination systems) from true anomalous cases.



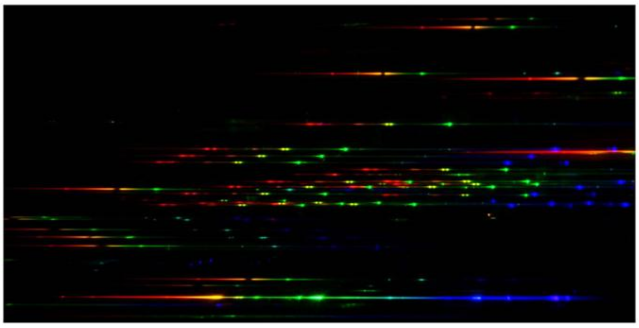
B. Testing new spectrograph

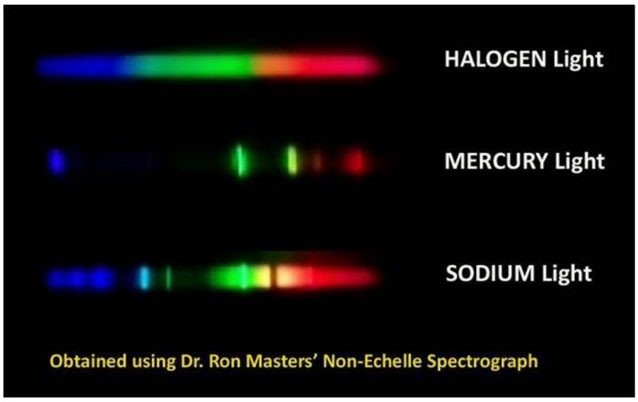
Physical chemist and spectroscopist Dr. Ron Masters has done a project for a wide-field and no-slit high resolution spectrograph. This system represents an optimum device in order to acquire spectral data of anomalous light phenomena ("nocturnal lights").

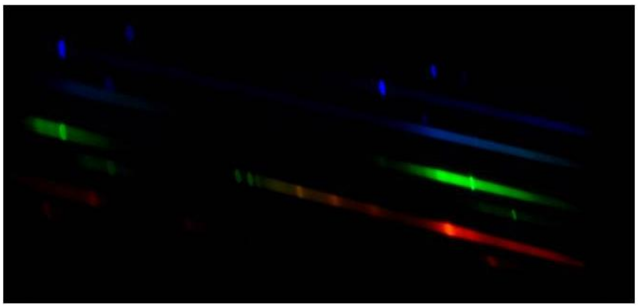
I have repeatedly been testing this instrument using streetlights. I have used two variants of this kind of spectrograph: low-dispersion (but higher resolution than a normal grating) and high-dispersion (of "echelle" kind, where spectra are spread over several spectral orders). Both kinds of spectrographs have been alternatively attached to a DSLR camera and to a videocamera.

The use of high-resolution spectroscopy, in particular, can help us to make true physics on anomalous light phenomena, due to a perfect line identification and to the possibility to study in detail line profiles. For instance if spectral lines are split in two parts this might be caused by the Zeeman effect, due to a very strong magnetic field produced by the light source. If we measure accurately such (possible) line doubling we are in a condition to measure the magnetic field intensity with no need to know light phenomenon's distance.

Here below some examples of my tests are shown.







Above. Low-medium resolution spectra obtained using a DSLR camera, a 300 mm focal length for the lens and a ROS spectral grating.

Middle. Low-resolution spectra obtained using Dr. Master's spectrograph.

Below. High-resolution spectra obtained using Dr. Master's spectrograph.

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Technical documentation on Dr. Masters's spectrograph can be found here:

1. Masters, R. A. (2012). "High-Resolution Slit-Free Direct-Viewing Multiplexing Field Spectrograph". *United States Patent Application Publication*. Pub. No. US 2012/0287430 A1 . Online at: http://www.freepatentsonline.com/20120287430.pdf
2. Masters, R. A. https://sites.google.com/site/fieldspectrographs/the-spectrum-of-our-sun---high-resolution

C. Project for an automated monitoring station

Since two years I am collaborating with an international research group of scientists lead by Dr. Mark Rodeghier of CUFOS. Our goal is to prepare a project for an automated measurement station in order to obtain measurements of such phenomena all the time, after choosing an appropriate location for the station. At the present time most of the attention is concentrated in two directions:

A) Optimizing the best optical sensors that are able to acquire data on weakly luminous objects after covering all the sky.

B) Optimizing the best grating system able to obtain spectra of good resolution. Gratings are intended to be attached to optical sensors such as *3i Cube* CCD camera.

The work above is presently carried out by spectroscopist Dr. Ron Masters.

Before these ongoing tests (aimed at spectroscopic measurements) – now being in a very advanced state – I have planned in detail what a monitoring station of "UFOs" should be. Here I present the excerpt of a paper that will be soon published, and which was presented by me in November 2013 at the Ohio State University.

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1. Automatic measurement station

What are the characteristics that an automatic station should have nowadays in order to obtain data that are able to satisfy a fully scientific procedure? The following points are probably the most important ones to point out (see also Figure 2).

A. Optimal Power Sources. A station that works all the time without interruption, except during maintenance, needs an efficient system that guarantees with reasonable continuity its power supply. Being batteries unpractical for this specific use or, anyway, of limited use in time, previous experience (PH, website) shows that long cables (with a length of the order of 1800 feet) can be used quite efficiently. Therefore such a station should be located at an optimal position, where an energy source is available (for instance: a house that is not too far from the station). This logistical problem must be accurately solved as the "battery option" is of very limited use in terms of time of utilization and would require periodic and very frequent battery changes or recharge, considering that more than one batteries should be used in order to serve several instruments inside the station. Due to possible black-outs, which might be caused both by bad weather and by the phenomenon itself (PH, website; Hendry, 1979), the cable system for energy supply should be coupled to a continuity module, which is ready to enter in function as soon as an energy failure occurs. A cable system is able to serve simultaneously all the measurement instruments in only one hit.

B. Station Multiplicity. In order to cover wide areas of a country (such as USA, for instance) it is inevitably necessary to implement several stations that are wisely spread in a targeted way over the country. The project might be started with two or three stations that are set up at strategic points of the country.

C. Effectiveness vs Costs. Due to the realistic availability of money funding and to the necessity of simplicity of maintenance, each station must be equipped with essential instruments that are both simple for use and at the same time sophisticated enough.

D. Range and Sensitivity. Every instrument that composes an automatically and remotely controlled monitoring station must be able to detect weak signals (comprising all wavelengths, ranging from radio to the ultraviolet if a complete system is used). This increases the possibility to record light phenomena that are away from the station but over the horizon. Typically such instruments should be able to detect and record signals coming from sources that are at least 10 miles away from the station.

E. Instrument Completeness. Every station, which is expected to be a compact "box", must contain inside several instruments (see Figure 1). The most important instruments that must be used are probably the following ones: one all-sky camera [6] connected to a low or medium-high resolution spectrographic grating, one triaxial fluxgate magnetometer [7], one electrostatic detector and one weather station. Such four instruments should constitute a "basic unit". An "optical unit", which can be added and connected to the basic one in a subsequent phase, should contain the following instruments: one high-sensitivity videocamera for taking videos [8], one high-sensitivity videocamera attached to a low-dispersion grating for optical spectroscopy, one DSLR professional camera attached to a dispersion grating for medium-high resolution of "echelle" kind, one specialized videocamera with the capability to record many frames per second [9] (high time-resolution; typically: 10.000 fr/sec), one specialized DSLR professional camera for infrared and ultraviolet photos [10], one optical radiometer. An "electromagnetic unit", which can be added and connected to the basic one in a subsequent phase, should contain the following instruments: one spectrum analyzer for microwave-UHF signals [11] (plus antenna), one receiver/spectrometer (plus antenna) for VHF signals (PSI, website; Strand, 1984), one receiver/spectrometer for VLF/ELF signals, one Geiger counter. A large part of the described instruments can be chosen among several high-quality models that are available on the market. All instruments must be computer controlled. A gravimeter (which is typically much heavier and more expensive than all the other instruments), a high sensitivity sound sensor and a thermal imaging camera might be added to the station if money funding will permit in a subsequent phase. All of such instruments must be of the off-the-shelf kind (namely: very portable, light and cheap) and connected directly to a computer server where data can be constantly recorded and then promptly downloaded from remote areas where investigators are located. The station needs a periodic maintenance both for the proper functioning of the instruments themselves and for an appropriate internet connection and efficiency.

Of course such a proposed instrument completeness, complexity and sophistication must be balanced against the cost and the available power source to run the instrumentation. But it should be reminded that the optical and the EM ones are just optional units (although extremely important for an appropriate and more rigorous physical study) that can be added only in a subsequent phase and only if results have been previously obtained using the

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[6] **All-sky camera.** A good example is given by the system used by NASA for fireball research: http://fireballs.ndc.nasa.gov/ A simpler but more dedicated system is represented by the "UFOCATCH" platform: http://www.ufo-science.com/fr/telechargements/pdf/ufocatch.pdf

[7] **Magnetometer.** A good example is given by the very portable and sophisticated *MEDA* fluxgate magnetometer: http://www.meda.com/

[8] **Multiple Videocameras.** Concerning the specific issue of videocameras an important point, due to Dr. Ron Masters (Masters, 2013), should be made taking advantage of previous projects (Gröschel, website) concerning the used frame rate and exposure times, where two videocameras are simultaneously used with different rates (1/sec and 25/sec) to optimize signal to noise (S/N) ratio. Such a procedure could be decided as an alternative to the basic videocameras present in the standard optical system proposed here. This would allow one to use correct exposure times to obtain best S/N ratio for the UAP of interest in an image frame. At the same time large dynamic intensity range would be gained so that dim and bright objects can be selected from images and not be over or under exposed (Masters). A third high-resolution system (camera or optical zoom) is needed (Masters' idea) that responds to the image location observed by the first two cameras to provide sufficient optical resolution to distinguish shape. This third camera system would use data from the first two cameras to point to the location of interest and set exposure conditions to provide best ability to discern shape. This idea is similar to how global observatory networks provide information to specific telescopes to point to an area of interest based on data obtained from other telescopes, such as when a supernova or some other interesting event is detected. This camera could also connect to a spectrograph (Masters' idea). Many systems could be deployed in many locations using the first two cameras. Hot spots could be equipped with the third system. Other types of detectors would be added to the equipment as the rest of the team decides, perhaps initially at the hot spot locations, then eventually to all locations.

[9] **High-speed videocamera.** A good example is given by the very portable and sophisticated *Olympus i-SPEED* : http://www.olympus-ims.com/it/hsv-products/

[10] **UV/IR DSLR camera.** Probably the best example on the marked is represented by the *Fuji FinePix S-3 Pro UVIR* : http://www.dpreview.com/news/2006/8/9/fujifilms3prouvir

[11] **Microwave spectrometer.** One of the best portable spectrometers of this kind is represented by the *Aaronia Spectran* : http://www.rtelecom.net/product/127/rf-spectrum-analyzer-1mhz-9-4ghz-spectran-hf-xfr-aaronia.html

basic system in order to justify further money funding. First one must be able to demonstrate that such a station is able to catch “UFO data”, then all the good reasons would come in order to implement more sophisticated instrumentation. Without considering the limiting factor per se in terms of time of utilization, if a battery option is used as an energy source evidently if the number of instruments increases the number of batteries must increase and the cost would increase as well with them. That’s the reason why a battery system is not viable both in practical and in economic terms. Past experience done with the Hessdalen station shows that a cable system can be used indeed. Therefore much of all the efforts should be concentrated in finding an existing appropriate power source in the vicinity of the station itself or not too far from it.

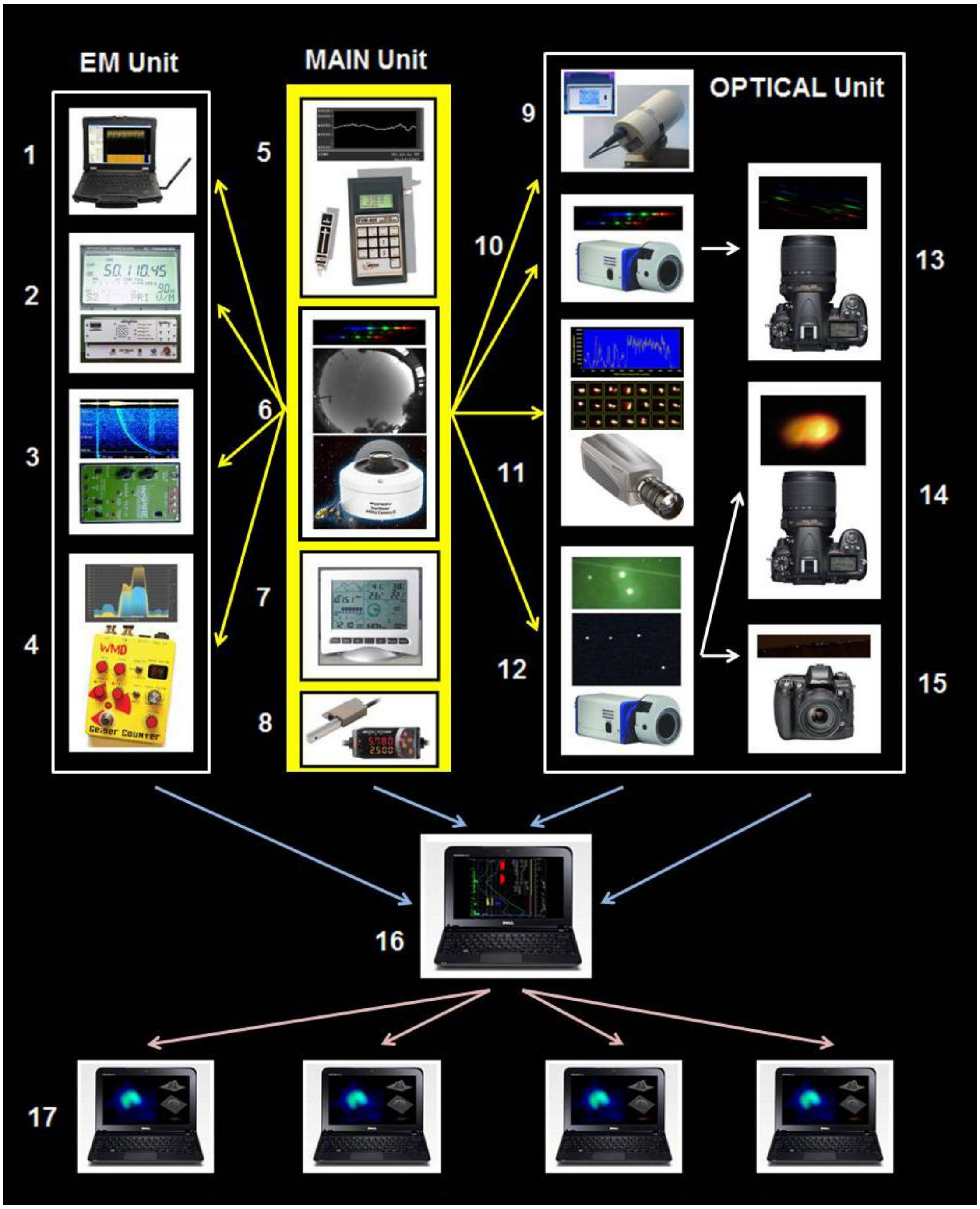

Figure 1. Automatic Station. 1) UHF Spectrum analyzer, 2) VHF Receiver, 3 VLF/ELF Receiver, 4) Geiger Counter, 5) Magnetometer, 6) All-Sky Camera, 7) Weather Station, 8) Electrostatic Detector, 9) Optical Radiometer, 10) High-Sensitivity Videocamera + Low-Resolution Grating, 11) High-Speed Videocamera, 12) High-Sensitivity Videocamera (normal + night shot modes), 13) DLRS Camera + Echelle Grating, 14) DLRS Camera, 15) UV-IR DLRS Camera, 16) Computer/Server, 17) Remote Computers.

F. Alarm device. An appropriate alarm facility must activate all the instruments together. Such a device might be constituted of a multi-instrument "EM box" [12] (able to communicate with the computers that control all the main instruments) or of the all-sky camera itself, which would be the only instrument that would presumably work all the time.

G. Station Location Choice. On the basis of which criteria is the location of the stations decided? Clearly maximum priority should be given where the incidence of UFO reports is more frequent in the country. This can be evaluated through an accurate statistical analysis.

H. Scientific redundancy. Instruments to be deployed at the stations must be able to be used for purposes that are also different from UFO monitoring. For instance, all of the available optical sensors can be used to monitor (and measure) the passage of meteors/bolides and fireballs in the sky and electric phenomena of the high atmosphere such as Elves and Sprites. This already partially happened with the instrumentation used during previous or current anomaly research. All the electromagnetic instruments might be able to monitor phenomena generated by geophysical causes (such as tectonic stresses near faults), by meteorological factors (storms in distance, atmospheric electricity), and by the activity phase of the Sun. Of course, in order to allow the employed instruments to be useful for standard science too, one will need to consult with various specialists to obtain their advice on what measurements they would find useful, in what format and with what sensitivity. If both needs (the study both of the anomalies and of natural phenomena) can match together, one would reach a solid and efficient multiplicative factor as well as an attraction pole for "standard" physical scientists, who indirectly (or even directly) might become interested (and involved too, in case) in the study of aerial anomalies too, thus bringing potentially the physical study of such kind of anomalies fully inside the academic environment.

I. Station Flexibility. Due to some practical reasons, a monitoring station can be intended in two distinct modes: a) as a permanently fixed station on ground; b) as a fully portable station. In the first case the station, although fixed for use, must be easily transported since it will have to be shipped to its final location, or shipped back for periodic maintenance. This mode seems to be considered realistic today due to the rarity of specific areas of USA (or Earth in general) in which aerial anomalies that show a systematically structured shape suddenly occurs in the form of time "flaps" at several locations. In the second case the station should be easily moved elsewhere in case of necessity, typically in order to monitor continuously several recurrence areas where Hessdalen and plasma-like phenomena occur. Due to this such a station should be placed over a little transportable wagon (equipped with wheels) to be attached to a truck, and, in case, also transportable aboard a cargo airplane. A decision on which of the two options must be adopted will depend on if one is more interested in monitoring highly anomalous structured aerial phenomena of probable artificial nature or if one is more interested in monitoring anomalous plasma-like phenomena of possible (but not assured yet) geophysical nature. In the first case the probability to find something is much lower than in the second case, but the importance to study structured aerial phenomena is so higher than the importance to study probable geophysical phenomena that the first mode should be chosen, also considering that anyway an automated station that records data continuously at a fixed location is expected to obtain results in time. This time – in terms of probability of finding something – is much longer than for natural-like phenomena's, but the much higher importance to study structured phenomena (due to what it might involve) justifies the fact that the first mode of making a station should be preferred to the second one.

J. Security against interference and intrusions. Stations must be placed at areas where no electromagnetic interference occurs due to human devices and where natural magnetic anomalies are not present. Therefore places that are isolated and safe at the same time must be chosen, but with the fundamental compromise in mind that a power source of the cable kind (located at an house, for instance) should be reasonably close to the station. Such a vicinity in principle should render the station much safer than if it is totally isolated (in which case a battery mode would be necessarily used as a power supply). A constant but soft control of the cops should be guaranteed too according to standard vigilance of houses, even the most isolated ones. In any fact the area should be fenced and an appropriate tag should be attached. As a permanent technician for the station's periodic maintenance might be of basic importance for the efficient and continuous functioning of the station, one could think of such a collaborator on site (in case more collaborators who take periodic turns among them) who momentarily is

[12] **UFO Multisensor.** A possibly useful "alarm device" might be represented by the "UFO Multisensor 1.0": http://digital-service.biz11.de/images/Dateien/c-Ufomultisensor%201-0%20englisch.pdf

accommodated at the same house where the power source is located for cable connections to the station. A similar mode (a private house close to the Hessdalen station) has been adopted in the recent past in Hessdalen by Italian engineers in order to allow the control of the radar screen. In such a specific case the power source was located at another house.

K. Occasional presence of investigators. In the case that a “UFO flap” (not only earthlights) occurs at a location whose contour (and/or “epicenter”) can be evaluated precisely and that such a “flap area” is a typically long lasting one, the automatic station should be placed there (Cornet, website). In such a case it would be highly recommendable that some investigators are also present in situ during some period of time: this might help to carry out additional measurements that a normal station is not able to perform. For instance, personnel on field might use portable telescopes both for imaging and high-resolution spectroscopy, heavy and sophisticated gravimeters, portable radars and other professional scientific instrumentation. Personnel might also conduct tests using a powerful Laser against a presumably anomalous light target after ascertaining – using a radio scanner – that the light phenomena are not airplanes.

L. Data processing and analysis. Data acquired using the measurement instruments that equip the automatic station are intended to be remotely downloaded by all the investigators that belong to this project. According to the competence data analysis is expected to be carried out by the specialists in several fields and, in case, shared with academic researchers and professors in order to profit from their technical response. More than one investigator should process the same kind of data, using the same or different software, while results must be compared together.

M. Hiring of Ph.D. students. It would be extremely interesting and profitable to involve young scientists (graduate students who already own a master degree) who want to work for their Ph.D. research in this specific field. Such students might be searched at Universities in the faculties of observational astronomy, experimental physics and optical and/or electronic engineering. They might be involved both in the data acquisition and in the data processing/analysis/interpretation phase. Such students should be supervised both by their academic professor and by the physical scientists/engineers who work directly in the project. Young scientists are notoriously very mentally fast and motivated, and being able to find at least one of them would be a great resource for the project.

N. Consultancy with engineering experts. The experience acquired on the data acquisition of UFO phenomena using automated stations is quite new and the technical experts (including technical personnel from the military in case) in this specific field are still very few in the world. Such experts should be promptly consulted and, in case, involved inside the project as external consultants. In particular, engineering competence might be extremely important when one deals with the desired data rate of the entire system. In fact, whatever the sophistication of the system is a time latency problem inevitably occurs at the time in which data are acquired. This causes a delay in communication between sensors within a given unit, and between units in the global network. The faster the communication and less the latency, the greater the cost. Accurate time stamp data for each unit in the network will be vital for relating observed events to each other, in order to allow an acceptable synchronization between all systems. A bad synchronization might prevent one to correlate two crucial events (especially the very short time-scale ones) recorded using different instruments, so that important information might be lost. Concerning electromagnetic sensors, problems related to the use of a PC interface, constituted by a microcontroller with buffers connected to each sensor and each USB bridge, could create self-interference (or intermodulation) and contaminate the sensors masking the results. Therefore the use of microcontrollers or bridges relying on cycles of clock should be reduced. If still a PC interface is needed, the compact 'box' would need either a real time remote connection via wireless network (through a cellular modem) or have its own record board with memory circuit that would be later assessed by the PC. The correct circuitry (where all circuits are properly connected) and microelectronics must be used in order to solve this problem: on the contrary data might be polluted by electronics itself. Considering these important issues of electronic engineering, which once properly faced would inevitably increase the cost of the entire apparatus, there are good reasons to suggest that at the same cost it is better to use less instruments but with such problems reasonably solved than too many instruments (even if absolutely important per se in order to face the physics of the investigated problem properly) for which data communication and PC interface are unsatisfactory.

2. Measurement instruments: procedures

The idea consists in starting the project using only the basic unit (or: "main system"), in order to test its functioning for a certain period of time and to verify if such a strategy is effectively able to record the passage of possible UFOs. The main unit employs an all-sky camera that is simultaneously able to acquire both images and optical spectra. Regarding the possibility to take spectra simultaneously with images, it is expected that a beamsplitter directs half of the light from the main lens to the entrance slit of the optical spectrometer, which can be of low or medium-high dispersion kind according to the choice that will be done. When a luminous phenomenon of whatever nature appears in the sky, there will be an increase in the intensity of the all-sky collected light. The all-sky background without the object is subtracted to obtain the spectrum of the luminous object. A recent aimed development and patented realization shows that a spectrograph for UFO detection (low and medium-high resolution variants) can be of the slit-free and direct-viewing type. At the same time in which optical measurements are taken, a magnetometer, an electrostatic detector (or electronic electroscope) and a weather station are expected to acquire data all the time. Obviously all of the four instruments are time-synchronized and connected together using one or more dedicated computers that pilot them and save the obtained data. If during a certain period of time (typically: one or two years) the basic unit demonstrates to be productive then the demand of new money funding would be justified in order to implement two additional units: the optical and the electromagnetic units. The scope of such additional units is to improve the monitoring procedure following a more analytic mode. Of course in order to achieve this task it is necessary to carry out a lot of engineering and informatics work, in particular in order to permit to the main unit to communicate with the additional two units. One "trigger parameter" must be chosen in order to permit the main unit to activate the other two ones. For instance, such a parameter might be given by the target's luminosity threshold or speed or by an alert coming from the magnetometer or the electrostatic detector. Moreover the Altazimuth coordinates of the target must be recorded continuously. In such a case the coordinates would be immediately communicated to all the instruments of the optical system, which then would start to track the target and acquire data of it. All the three videocameras and the radiometer are expected to be mounted on a solid steerable tripod. A second steerable tripod would have all the three DSLR cameras mounted over it as well. All the operations using the main system and the optical system would be synchronous with the operations using the electromagnetic system, which would be activated by the trigger parameter from the main unit. Computers (certainly more than one, or a single powerful workstation) are intended to control: a) the Altazimuth movement of optical instruments; b) all the data acquisition operations. Data are then deposited on a memory storage disk, and can then be downloaded from remote stations for analysis.

3. Physical parameters to be obtained

All the measurements that are acquired using all the described instruments (see Figure 2) must permit investigators to obtain a possibly accurate evaluation of the most important physical, geometric and kinematic parameters (Kitchin, 2008; Lang, 2005) of the luminous flying target. According to the used instrument it is possible to obtain the following physical parameters:

MAIN UNIT

- Electrostatic Detector – Number of electrostatic particles per second.
- Weather Station – Atmospheric parameters (air temperature, pressure, humidity, wind speed, clouds, etc.).
- Magnetometer – Magnetic field intensity (x, y and z components).
- All-Sky Camera – Apparent target luminosity and color (using photometry). Light surface distribution (Point Spread Function). Angular speed of the target in the sky. Spectrochemical line identification. Intensity and equivalent width of spectral lines (if present), from which it is possible to: a) calculate the number of atoms of a given (identified) chemical element that are excited; b) measure the flux of the continuum spectrum.

OPTICAL UNIT

- Optical Radiometer – Electromagnetic radiation intensity in the optical (and, in case, in the near IR and UV too).
- High-Sensitivity Videocamera – Kinematic characteristics of the target (speed, acceleration, changes of directions). Angular speed of the target in the sky. Apparent target luminosity and color. Light surface distribution (Point Spread Function).

- High-Sensitivity Videocamera + Low-Resolution Grating – Spectrochemical line identification. Intensity and equivalent width of spectral lines and their variation with time.
- DLRS Camera + Echelle Grating – Spectrochemical line identification. High-precision intensity and equivalent width of spectral lines. Morphology of spectral lines. Magnetic field intensity from possible Zeeman Effect that is in case present in spectral lines. Possible line blue or red-shift in case of extremely high speed of excited gases. Possible rotational line broadening.
- Optical and UV-IR DSLR Cameras – Apparent target luminosity, color and light surface distribution from high-resolution photographs, in the infrared, optical and ultraviolet ranges.
- High-Speed Videocamera – Possible high-speed variation of luminosity, color and surface shape and dimensions from optical video frames (typically: 10.000 fr/sec).

ELECTROMAGNETIC UNIT

- VHF and VLF/ELF Receivers and UHF Spectrometer – Intensity, variation, periodicity and morphology of radio waves in the UHF, VHF and VLF/ELF ranges.
- Geiger Counter – Intensity of radioactivity emission (alpha, beta, gamma particles).

Clearly, being all the measurement instruments working all the time and all together simultaneously, it becomes possible to: a) evaluate the time-variation of all the measured parameters; b) search for correlations between them. From this it may be possible to infer some important information on the physics of the problem.

Apart from inevitable limitations for the use of spectrographic systems and the optical radiometer – except for the case in which the target is very luminous, being the background emission of the sky known – all the other instruments that are implemented inside the automated station may permit to furnish important information about diurnal anomalous flying phenomena too, in particular about their kinematic and morphologic characteristics in the optical and in the infrared and all the magnetic, electromagnetic and radioactivity parameters.

Concerning photometric and geometric parameters of such kind of flying target, it is evident that, until its distance is not known, what we can obtain are only their apparent value. In order to obtain their intrinsic value we need to obtain the distance parameter. In the absence of a radar or a Laser range finder – which might be anyway implemented inside the station in a further phase – triangulation is the only way to obtain distance and consequently the intrinsic (linear) dimensions and the absolute luminosity of an extended target. In order to achieve this goal it is necessary to place a further videocamera or DSLR camera at some distance from the main measurement station (PH website). Assuming that such an external optical device is working simultaneously with the optical devices that are working inside the station, it is then possible to obtain the target's distance whose precision will the higher, the higher the used baseline (distance of the station from the external optical system). At this point we are in a condition to pass from the measured apparent luminosity, angular velocity and angular dimensions of the target to intrinsic luminosity, linear (projected) velocity and linear dimensions. Once the distance parameter is acquired our physics action is completed. Such procedures are identical to the ones used in astronomy.

As Dr. Mark Rodeghier rightly noted, having several types of optical instruments is ideal, but this might not be financially viable, so such devices should be ranked in terms of optimal scientific value versus the cost and complexity. Such a specialized optical unit in general is obviously an (extremely important per se, in physical terms) opportunity that might be employed in the (more or less near) future only if the data previously obtained from the main unit are in case so crucial to justify a further money funding. According to the obtained money funding it might be possible to further implement all the listed optical instrumentation, or only some components of it with a possible priority given to the high-sensitivity videocamera plus its attached low-resolution grating and to the high-speed videocamera. Further optical instruments might be added in a subsequent phase (if the necessary money funding is sufficient), considering that anyway a container of them should be prepared since the beginning to contain all the proposed instruments of the optical system. It is anyway clear that, apart from the costs, when the complexity of the system increases the global efficiency of the entire system might decrease as well at times. Of course the best compromise between complexity, costs and physical prominence of the data that are expected to be obtained, can be discussed according to which priorities will be decided.

Original paper to be published at the end of 2014 on the UFODATA website:

Teodorani M. with: Rodeghier, M., Masters, R. & Ailleris, P. (2013). "Project for a network of automatic stations for UFO monitoring". *First UFODATA Workshop,* Ohio State University, Columbus (Ohio, USA), November 1, 2013 (25 pages).

D. UFOSPECNET (UFO Spectroscopy Network)

UFOSPECNET was a scientific initiative created by me 10 years ago. The goal was to teach people who live at areas where recurrent anomalous "light balls" are reported, to take spectra themselves of the phenomenon. This operation was quite successful with observers from Canada, Australia and North Italy. These (very dedicated) persons attached a ROS (Rainbow Optics Spectroscope) transmission grating to their DSLR cameras and sometimes they obtained accurate spectra of the light phenomenon in their area. The procedure was as follows: after taking (in addition to photos and videos) spectra they were sending them to me so that I could analyze them, after calibrating them in wavelength. Technically the operation worked quite well. But scientific results were a bit disappointing due to the type of the obtained spectra: continuum spectra and no spectral lines in them as I was expecting. In any fact (especially the ones from Avalon Beach, Australia) some of such spectra showed a double-peaked continuum, which is not typical of airplane headlights, but which could be anyway produced by a mixture of manmade illumination systems (such as fluorescent lights). Some of the spectra that were sent to me were clearly identified to be due to manmade causes. Anyway the strategy to make people take spectra of anomalous light phenomena in their areas, sooner or later might produce something scientifically interesting. Such a preliminary "scout spectroscopic operation" carried out by dedicated people on site might justify subsequent expeditions to the area using all sorts of professional measurement scientific instruments.

I would like that the UFOSPECNET initiative starts again. How to do that? It is very simple: a ROS grating must be attached to a Skylight filter which in its turn is attached to the zoom lens of a DSLR camera used at high resolution (10-20 Megapixel, typically). People take the spectra (not an easy operation, but anyway very feasible with a little engagement) of the anomalous light phenomena, and then send them to me so that I can carefully analyze them after calibrating the spectra using RSPEC or VSPEC analysis software. Sooner or later, some important scientific results might come out.

In addition to professional DSLR cameras, people can also attach the ROS spectral grating to simpler compact digital cameras or even to the cameras of smartphones after doing some very simple custom-built operation, especially using a simple CD (just the external film that covers a compact disk) and placing it in front of the entrance of the smartphone camera (as Dr. Ron Masters has lastly suggested). A further suitable technique is to attach the ROS grating to (good quality and resolution) videocameras or handycams: in such a way we can see if and how the spectrum varies with time. That's low spectral resolution, of course, but sometimes surprises might come out, especially if very strong emission lines are detected in the spectrum.

I can furnish to people, in distance, all the technical details of the procedure in order to take spectra. Meanwhile people can do exercises by taking spectra of streetlights. It must not be forgot that (apart from the exercise with them) some streetlights (in particular Sodium and Mercury illumination systems) are often used as calibration reference spectra. So if external observers are able to take spectra of the "mystery lights" they must send to me both the spectrum of the anomalous light and the spectrum of the reference light, so that I can first calibrate them in wavelength using suitable software and then analyze them.

Spectroscopy (I have a long experience with it) is extremely important because it allows us to obtain fundamental physical parameters of whatever emits light, such as temperature, pressure, density, chemical composition, and sometimes magnetic field intensity too. Sometimes even an "amateur spectrum" might allow us scientists to make important discoveries on such strange lights, just thanks to people’s contribution, dedication, engagement, determination and passion for science.

There are good reasons to think that if normal persons are educated to take spectra using the camera of their smartphones the number of data of potential scientific relevance might increase of many orders of magnitude.