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Spherical Unidentified Anomalous Phenomena: Scientific Observations and Physical Hypotheses, Danger Evaluation for Aviation and Future Observational Plans

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Abstract
Spherical unidentified anomalous phenomena (UAP), of both plasma and solid-like kinds, have been often observed in the world. Several monitoring campaigns have permitted us to know some structural properties and the time behaviour of such objects. On the basis of what has been observed so far, of the deduced constants characterizing the phenomenon, and of the consequent physical working hypotheses that resulted, possible dangers to aviation are examined from several point of view of physical science by taking into account both a natural and an artificial nature of this kind of UAP. A systematic instrumented observational plan is proposed, involving both recurrence areas and time flaps of the phenomenon itself.

Introduction

Sightings of anomalous light phenomena of spherical shape have been reported from several locations in the world. Most of them have been classified as "earthlights" (Adams, website; see Fig.1). The appearance of this kind of unidentified aerial phenomena, in general, doesn't show a solid structure or the clear evidence of a surface, but it looks more often as a very bright spherical object having a much less smoothed contour than the one shown by standard plasma. Most of these events have been documented by visual sightings; more rarely they have been videoed, more often singularly, in other cases flying in a sort of formations. Only a few of them have been monitored using scientific instrumentation. At the present time many are the videos showing on internet the alleged evidence of this kind of anomalous spherical objects, but the amount of fakes and hoaxes that are being persistently perpetrated (Teodorani, 2009b) is so severe that a scientific examination is limited only to a very few ascertained cases. The first part of this contribution will be dedicated to the description and discussion concerning observations that have been carried out using scientific methods, and which will deal mainly with spherical phenomena of the plasma kind. 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 work hypotheses on the possible physics of these phenomena are ventured and reasoned but not definitively established, as this can happen only when the obtained data are in sufficient number and when they are obtained using more wavelength observational ranges than the ones that have been carried out so far and guaranteeing a better simultaneity of different measurements instruments together. The second part will deal with some reasoning through which it will be attempted to predict qualitatively a possible dangerous interaction of such spheres with aircrafts, on the basis of their observed physical behaviour. Along with this topic an ample discussion of physical theories and scenarios will be presented, trying to cover several fields of physics and its possible connections. The third part of this preliminary study will regard an observational research plan, in which new specifically aimed instrumental observations are intended to show more evidences that can furnish to us a more complete physical picture of what is seen and to prove or confute work hypotheses concerning the possible nature of spherical UAPs. Only after this will be accomplished we'll be in a condition to evaluate precisely the level of possible danger to aviation and/or generally to human activities. This is extremely important, because if we start too early to do calculations or evaluate an order of magnitude of the expected physical quantities, we risk to settle quantitatively an incorrect picture of the phenomenon (whose "map" might be very different from the true "territory") and consequently to produce an unrealistic and incomplete evaluation of the threat that this phenomenon might constitute for human activities. New and many more quantitative data are now necessary, in order that we are in a condition to integrate them with the useful statistics obtained from selected witness cases. The possibility that "light spheres" do not appear only as plasma objects but as solid artificial ones too is also ventured throughout the entire report, both in form of hypotheses and in form of important witnessed sightings coming from some parts of the world.

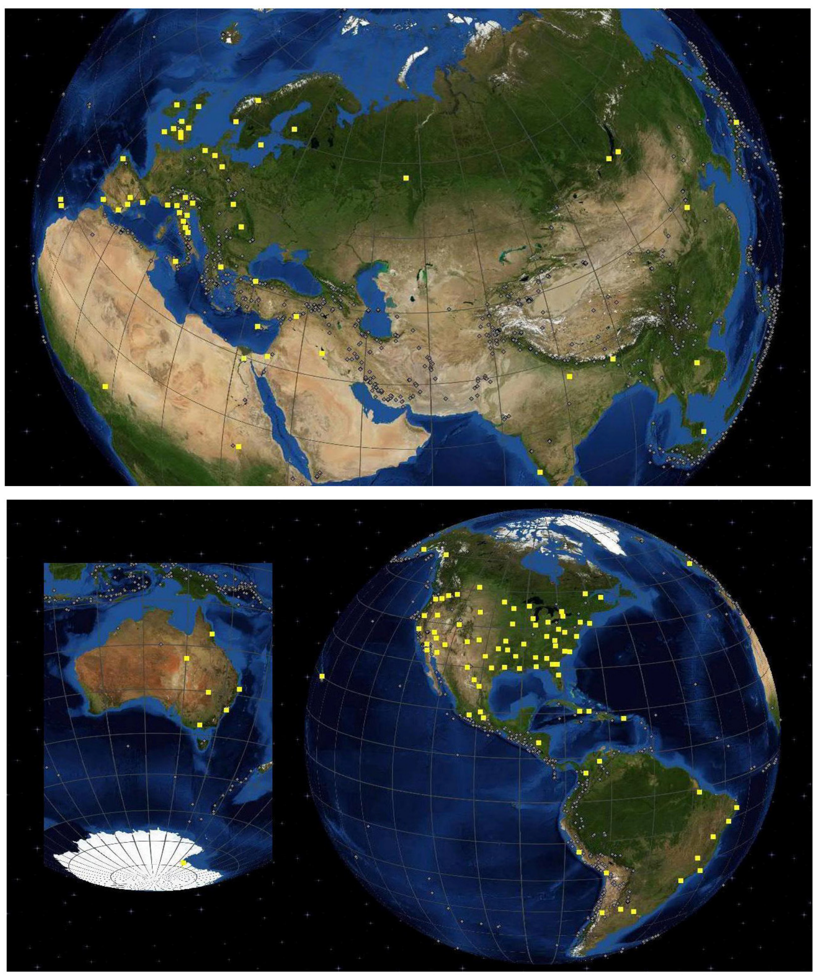


Figure 1. World distribution of locations (yellow squares) where anomalous light phenomena of the "earthlight" kind occur more often, according to witness reports (author's processing). Small brown dots represent fault areas.

1 – Scientific Observations

Spherical shaped light phenomena, when not diffused as dubious videos on Youtube or other channels of popular audience, have been confirmed as an existent phenomenon through some scientific studies that have been carried out at locations where this kind of phenomenon shows to be reasonably recurrent (Adams, website; Akers, website; Bunnell, website; Long, 1990; Pettigrew, 2003; Rutledge, 1981; Stephan et al., 2009; Strand, website, 1984, 1996; Straser, 2007; Teodorani, 2004a, 2004b, 2008; Warren, website). The Hessdalen valley in Norway is probably the prototype of these special locations, not just due to the many events that are reported and videoed (and sometimes occasionally measured) but because the existence of a permanent measuring station there and the occurrence of many international missions in the area, make of this location a sort of "laboratory area" that is very well suitable for the investigations of physical scientists in general (Strand, website). It can be now confirmed that similar reoccurring phenomena are sighted in other areas of the world too: for instance the Brown Mountain (Warren, website) and Marfa light (Bunnell, website; Stephan et al., 2009) phenomena in USA and the Min-min phenomena in Australia (Strand, 1996; Pettigrew, 2003) are quite well known and also scientifically monitored.

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

1. They are most often of spherical in shape, of different colours, mostly white, of often long duration (up to 30-60 min, spaced out by moments of "off" and "on" phases) and quite 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 together (Stenhoff, 1999). These phenomena have been provisionally ascribed to the class of "earthlights" (Adams, website). Yet such phenomena, 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 able to emit often a high level of radiant energy. The most credible measurement attributed to them a power of the order of 20 KW in the optical. They are most often unstable in luminosity and they are subject to a regime of light variability at the rate of a few seconds or less, with no periodicity. Variability is irregular. They can turn on for some minutes (while pulsating) and be turned off during a similar time. When they are turned off in the optical, they sometimes might be still (and often strongly) strongly visible if a night vision system is used.

3. The mechanism that determines their irregular pulsation, which causes an only apparent inflation of the light surface, is now quite well known from instrumental observations. The inflation is not due to the expansion of the spheres themselves but to the sudden apparition of many smaller spheres (see Figs. 2, 4) that gather together around a common barycentre and that multiply and "reproduce" themselves in a very short 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:

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

where $D = 2R$ is the intrinsic diameter of the light cluster (**R** is its intrinsic radius), d is the distance from the observer, $P_E = 4\pi \cdot R^2 \cdot K$ is the luminous power received 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 luminosity variation, assuming that here we deal with an isotropic radiator. 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. 3), 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 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. 6) or to an external electrochemical mechanism mediated by water vapour and aerosols that is able to confine them from outside (Teodorani, 2004a, 2008; Turner, 2003; see Fig. 6). 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 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 to cool: the "off-luminosity" phases are suspected to be one of the main self-regulating regimes that prevents these spheres from liberating their energy explosively when the temperature is too high within a too small confining volume (see Fig. 3). 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 looked by sight these light phenomena appear just like single occasionally "inflating" spheres, but a more careful observation shows that they are composed of many secondary spheres whose appearance and disappearance cause the observed light pulsation. In addition to the Hessdalen case, a similar behaviour, such as the one described here, has been reported by witnesses who observed the same kind of phenomenon in the case of the Min-min lights (Strand, 1996) in Australia and the Hornet and Paulding lights in USA (Teodorani, 2008).

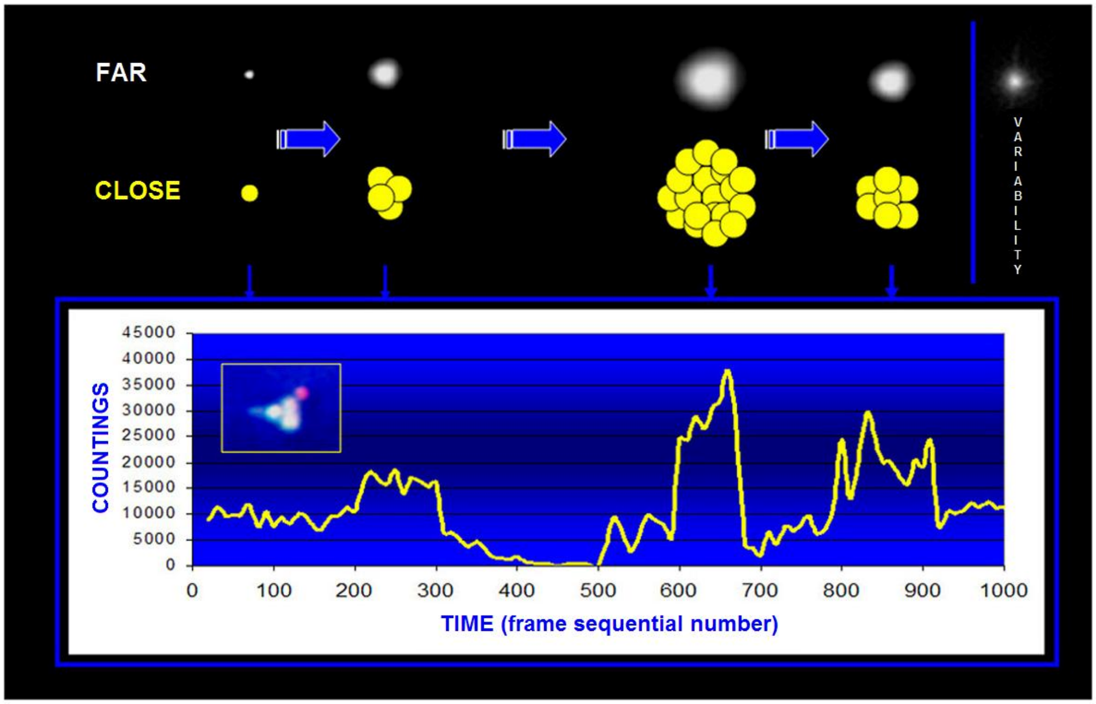


Figure 2. The "clustering effect" manifested by the light spheres observed in Hessdalen: observed "light spheres" are in reality composed of many secondary spheres, whose number increase is the main cause of light variability.

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

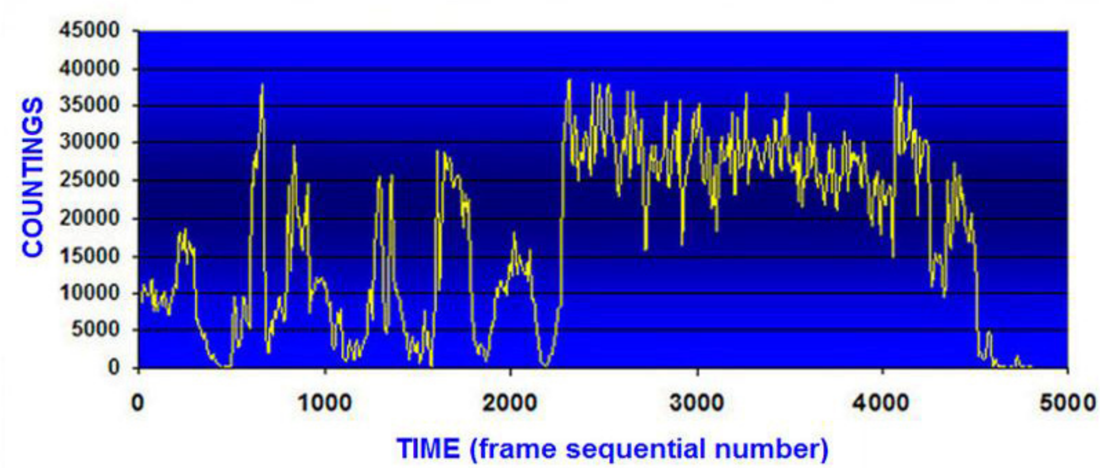
5. The very few optical spectra obtained of the light phenomenon do not show a "unified pattern" (such as the one of a star of a given spectral type, for instance). This means that such a phenomenon doesn't contain specific chemical abundances of its own but its spectrum is strictly dependent on temperature, density and pressure of the air where the localized heating occurs, and also on the position of the light phenomenon compared to the ground. In fact if the phenomenon occurs close to the ground, as it happens very often (see Fig. 4), it can produce a spectrum that reflects the composition of the soil. Sometimes, if mold spores are approached by the onset of a plasma regime the optical spectrum can simulate semi-conductive characteristics showing a LED-like spectrum (Teodorani, 2004a). Therefore spectra vary according to several parameters and do not constitute a fixed "unchangeable identity paper" of these objects (Teodorani, 2008; Warren, website).

6. The light phenomenon shows quite often a radar track (Strand, 1984), and anomalous radar signatures can be recorded also when a luminous phenomenon is not in sight (Montebugnoli et al., 2002). This is very interesting because it might indirectly demonstrate that also when the plasmoid is invisible it is possibly emitting in the infrared too as low-energy plasma. This might be confirmed 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 are of spherical shape, but a few cases do exist in which different shapes have been encountered and where such a spherical shape changes into something else. Some examples (see Fig. 5) of such anomalous shapes have been recorded by this author in the course of his scientific expeditions in Hessdalen, Norway, in the years 2000, 2001 and 2002 and in the Apennines of North Italy in 2005, and analyzed by the same author from data coming from Avalon Beach, Australia (Teodorani, 2004b, 2008).

8. A time correlation with magnetometric measurements (Strand, 1984, 1996) and/or with VLF-ELF measurements is occasionally confirmed and/or strongly suspected (Teodorani, 2004a, 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 from time to 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).



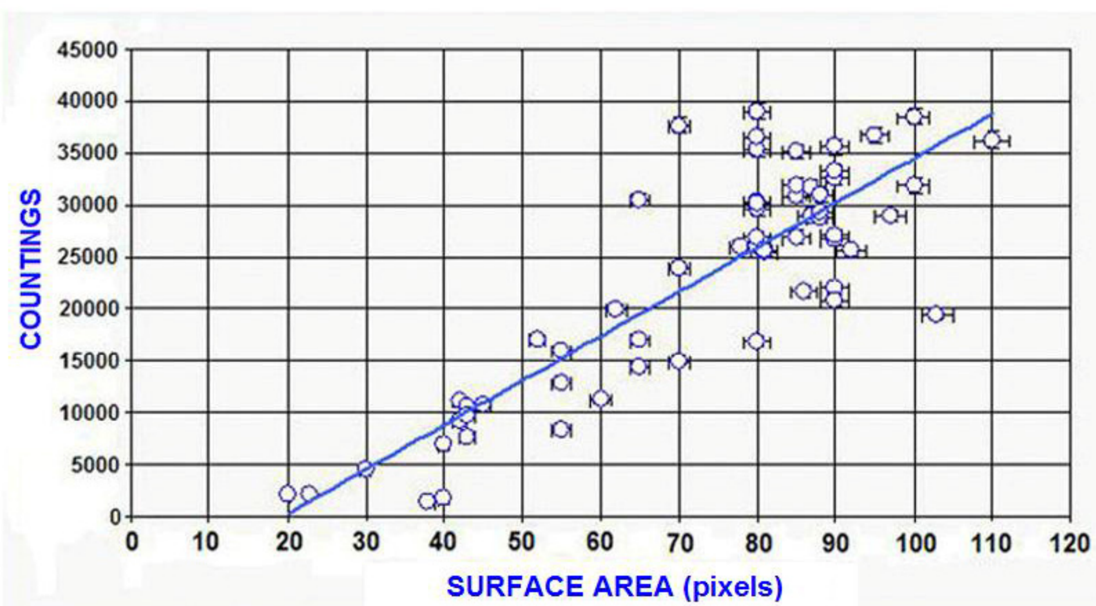


Figure 3. *Above*. Time variability during 3 minutes of the luminosity of one light phenomenon phenomenon (composed of many secondary clustered spheres) observed in Hessdalen, July 2001. Data were taken using a Canon TM-1 professional videocamera. *Below*. Correlation between luminosity (countings) and surface area of a light phenomenon characterized by a "clustering effect".

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. 4, Teodorani, 2004a).

10. Many witnesses report that such phenomena tend to approach very often 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).

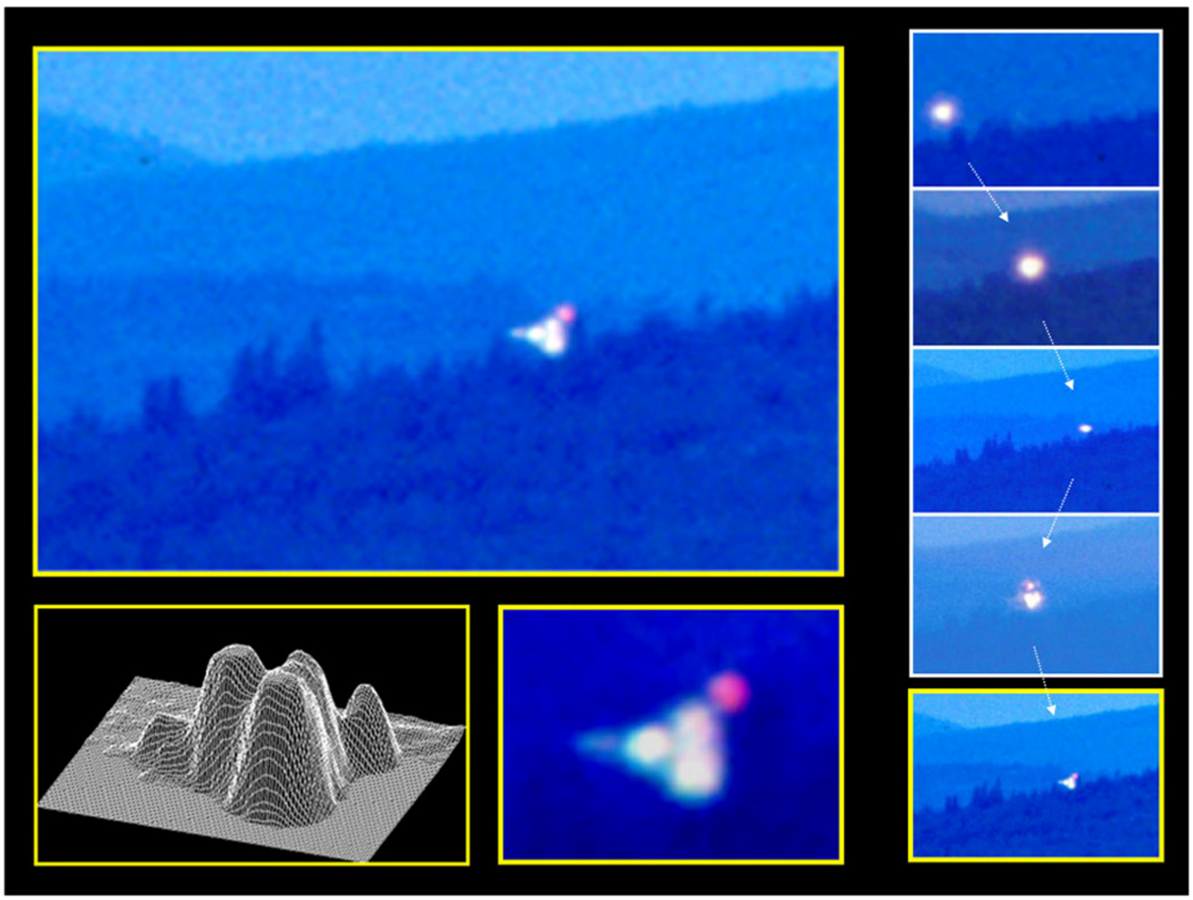
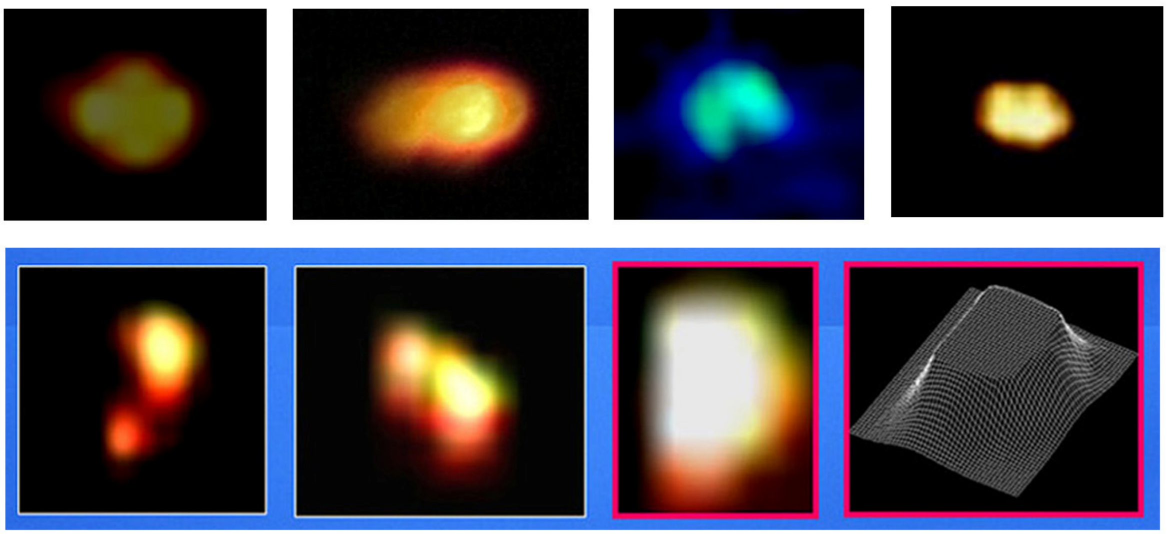


Figure 4. One example of a multiple light-ball photographed by this author in Hessdalen, July 2002. Shape and dimensional variation is also shown on the left.

These are the essential observational elements that can be technically described by observations carried out so far, according, at least, to the investigations of this author and its comparative studies with other investigators. It is out of the scope of this part of the presentation to discuss in details the theories and/or work 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 geophysical nature, in particular piezoelectricity, triboluminescence and the more recent and complete P-hole theory (Freund, 2003; Teodorani, 2004a, 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, 2004a, 2008; Turner, 2003; Zou, 1995).



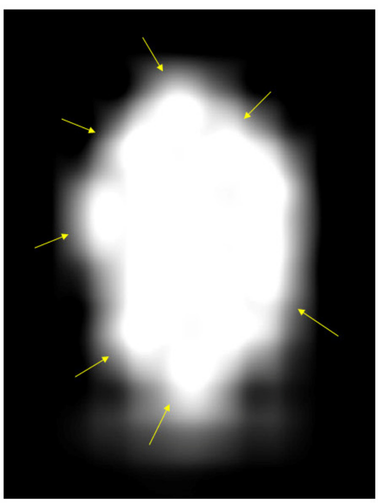


Figure 5. *Above from left*. Peculiar shapes of plasma-like phenomena analyzed by this author from data taken by Chris Beacham (first photo) at Avalon Beach (Australia), and recorded (second photo) by this author in Casalbono (Northern Apennines, Italy) and Hessdalen, Norway (last two photos). *Center from left*. Sequential shape variation of two light balls into a rectangular shape (Hessdalen, 2001). *Below left*. Rectangular shape surrounded by spherical light balls (Hessdalen, 2001).

These images may be compared with others presented in 3.2.1 and 4.2.4 (Ed.)

What is of interest here, once all the observed characteristics (that are available so far) are fixed quite clearly as an overall constant of the phenomenon, is to try to predict what are the effects that these light phenomena can cause in the environment and our technological devices, such as for instance aviation and its safety. Therefore we should now analyze critically some of the described characteristics and try to make consequent deductions concerning the main point of pertinence: aviation safety (Haines, 2000; Haines & Roe, 2001; Roe, 2004). This point will be made along with a quite detailed discussion of physical hypotheses that might stand upon the nature of such phenomena in general.

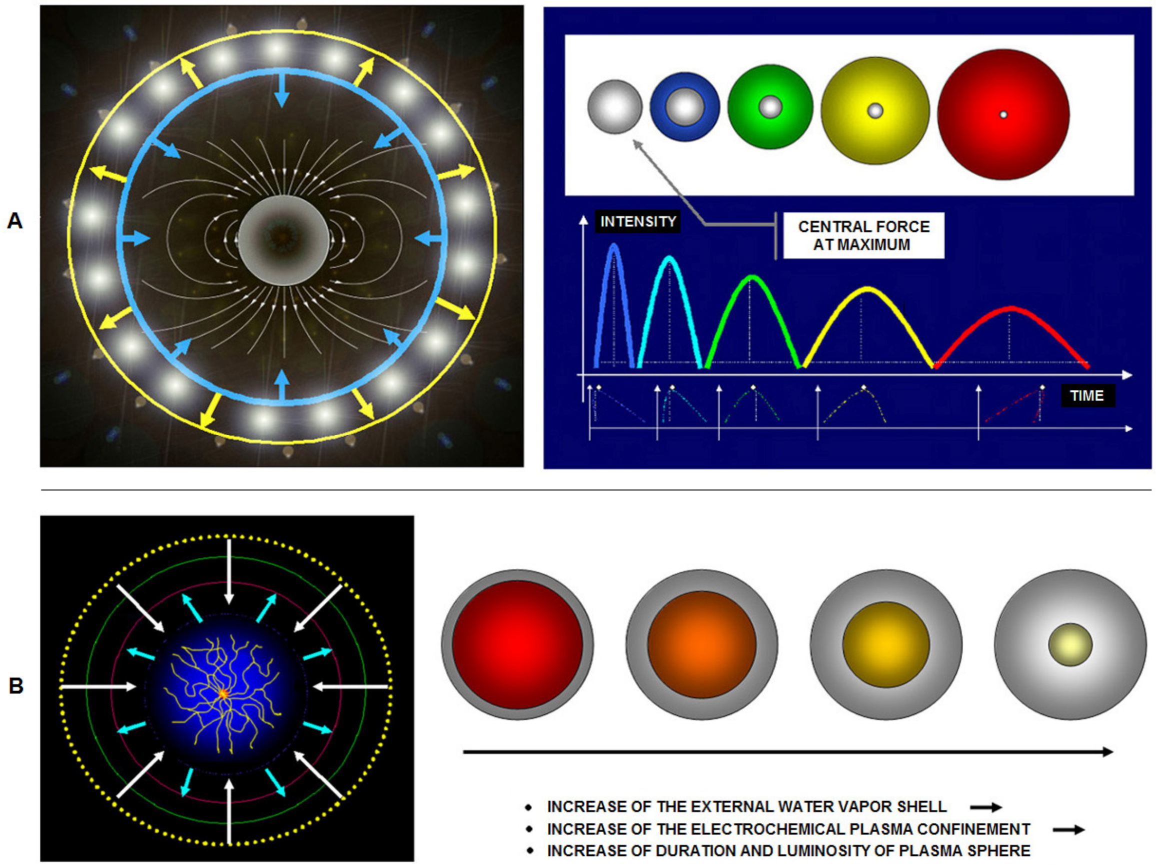


Figure 6. Two alternative models proposed by this author in order to explain plasma confinement mechanisms inside a “light sphere.” *Model A*. Plasma trapped by a central force represented by a strong magnetic field in the center of the light ball, where an adiabatic expansion and cooling of the plasma sphere, showing a color change from blue to red, 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) mediated by increasing water vapour and aerosols balancing the outward adiabatic expansion of the plasma.

2 – Physical Hypotheses and Interaction with Aircraft

Some spherical light phenomena have been seen quite often close to airplane fuselages while the airplane was flying (Haines, 2003; Haines, 2007). A similar phenomenon occurred during WW-II giving rise to the sighting of so called “foo fighters”[1] repeatedly witnessed by military pilots. Similar spheres have been seen (and filmed) going from up to down in the streets of some cities. Popular ufology uses to call these phenomena “probes”, meaning in such a way that these ones are “scout devices” sent from larger airships of alleged exogenous origin. Recorded videos show in general no evidence of pulsation such as in the case of plasma spheres described in the previous section; otherwise they show a not well-defined surface contour of such flying spheres. Therefore there is still much doubt if these spheres are structured metal-like objects reflecting sunlight, unstructured plasma objects, structured objects producing some plasma on their external surface, or all kinds of phenomena together. One interesting fact should be clearly noted in this specific context. The Hessdalen area, to which most of the previous description of plasma light spheres is referred, has shown also something

[1] Also called “balls of light,” “balls of fire,” “Feurball” (German), “Kugleblitz” (German).

that might really make one suspect a “probe nature” of some of these spheres: this can be seen in a video recorded in December, 4, 1999 (Strand, website), which shows quite clearly the evidence of a little light sphere that becomes suddenly reunited with a much larger totally lighted object of undefined shape (just vaguely triangular). This raises a quite hard problem in the Hessdalen-like research in general, because from time to time something that doesn’t seem just plainly “natural” overlaps with a more general apparently natural plasma anomaly of geophysical origin. The question is still maintained as the following, and no definitive answer to it exists yet: is really something “additional” (Teodorani, 2006, 2008) occurring in these areas of geophysical reoccurrence of light spheres or is this apparent discrepancy only one of the shapes that apparent plasma spheres can acquire occasionally? The same “overlapping phenomenology” has been witnessed also elsewhere: in Avalon Beach, Australia (Beacham, website), in Piedmont, USA (Rutledge, 1981), in the Northern and Central Apennine Mountains [2] in Italy, just to cite a few examples.

We do not know yet if plasma spheres and more structured ones are two different aspects of the same phenomenon or if two different phenomena (one natural and one artificial) occasionally overlap together in space and in time. Clearly if the first hypothesis is true geophysical hypotheses concerning earthlights might need to be, at least partly, revised. We still have to find an answer to this very crucial question.

Of course we can venture a lot of elaborated alternative hypotheses but this would be premature to the scope of this work, which is intended to be pragmatic and not speculative. In fact what we are interested in here is to evaluate, regardless of the origin of light spheres, how and if this kind of phenomenon can constitute a danger to our technology and to us.

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[2] Personal sighting of a white spherical UAP. Concerning spherical unidentified aerial phenomena, I need to report here a visual sighting occurred in July 9, 2007 (Teodorani, 2008) together with a colleague of mine (physicist Gloria Nobili). We were both at the same time witnesses of a spectacular visual and daily sighting in the mountains of Central Italy. The "ball" was totally white in color, it was flying at very low height just a bit over tree tops, so it was quite easy to determine its approximate dimensions (not more than 50 cm in diameter). The shape was perfectly spherical and it was behaving as a remotely piloted "drone" of some kind. This sphere, of perfectly constant luminosity, appeared to have a structure and quite sharp surface contours, with no resemblance of plasma balls such as the classical Hessdalen-like ones. The time of the day was about 12:30, while we were having lunch at a little restaurant just outside. From there we could see the mountains (Monti Sibillini national park) very well and very close to us. The place from where we had the sighting was Castelluccio, a very little hamlet belonging to a wide plane named “Piana di Castelluccio”, and Monte Vettore was the specific mountain where the spherical UAP was just sighted by us the first time. My colleague was in front of me at the lunch table and she suddenly saw first the thing. I suddenly turned back and I also saw it very well: we then locked on to its path until it disappeared. At first I thought of a large bird or so, but soon I realized it wasn't. The white sphere crossed diagonally the mountain from the base to the top, and it took about a minute to reach the top. It then disappeared and after another minute or so it reappeared then on the top of a mountain behind Monte Vettore, just using the same very low-height flight mode as the first time with the first mountain. Its velocity was constant with no acceleration, the regime of motion was linear but it possibly jumped sideways once. It seemed it was using a sort of TFR (Terrain Following Radar) in order to avoid trees and rocks and I estimated that the height of its flight was about 5-10 meters over the fir tree tops (in the low part of the mountain). Weather conditions were: perfectly clear and sunny. It was apparently a technological object but it was not shining silver metallic, otherwise it was just white and a little intrinsically bright. I might suspect that such a thing might be a sort of new military experimental UAV, but I am not sure at all of that: it was objectively too unusual, and its brightness didn’t seem to be produced by sunlight reflection. Unfortunately all of our measurement equipment was inside the car as we didn't expect to see it at daylight; it was just a surprise to us (we normally monitor the situation during the night). So we couldn't take any photo or video at that precise time. Anyway, the day later I took a lot of normal and infrared survey photographs of that area (all around), just to see if we could catch it again flying somewhere there. In fact we caught it in photo once (flying aside another mountain there), even if the quality of the photo is not good at all and the weather at that time was quite foggy. The best conditions to take a photo of this "sphere" was just during the first (visual) sighting, both due to much more closeness and much better weather. Unfortunately we missed the best occasion to document it.

It has already been said that more classic "earthlight phenomena" tend to occur very often close to the ground (an example is shown in Fig. 4), but similar light balls have been seen high in the sky too. Assuming that – as we expect and sometimes measured – these light balls may be associated to a more or less intense electromagnetic, magnetic or electrostatic field, it is obviously strongly suspected that this can in principle occasionally interfere with the electrical equipment and with the electronics of vehicles on ground such as cars. Cases of car transient malfunction or blackout are not uncommon, even if most of these cases are purely testimonial and only occasionally relative to unstructured light balls. Some valuable quantitative examinations of areas that were affected by an anomalous magnetic field after a UAP sighting have been done in some cases (Maccabee, 1994). One example of the evidence of occasional blackouts or power failures – in this specific case of measurement equipment – comes from the first intensive monitoring campaign carried out by Project Hessdalen in 1984 (Strand, 1984), and this happened mostly when spherical lights were sighted or approached observers.

In both cases – cars and instrumentation – a blackout can be quite troubling but not necessarily dangerous, but it can become seriously dangerous when this happens to airplanes or helicopters [3]. That's the reason why we should interrogate ourselves on how and how much this kind of phenomena, according to the observed characteristics that have been observed in detail, can create a danger to aircrafts.

Let's try to reason on this by points, according to the branch of physics that might be involved when such spherical UAPs interact with airplanes. What we can construct here is not yet a well-settled physics but only several possible physical scenarios that might be expected by such an interaction.

1. Thermal energy. – When the phenomenon is not interacting with the environment other than the air in the sky, the produced energy (radiant power has been derived in a few UAP cases: Maccabee, 1979; Teodorani, 2004a; Vallee, 1998) is expected to operate in two different ways according to which kind of "spherical phenomenon" is involved, namely a spherical plasma condensation or a possibly artificially propelled spherical probe.

In the case of a plasma sphere, it is expected that the heat produced by the plasma can be converted into ionization and excitation of the surrounding medium (Lang, 1998; Sobelman,

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[3] The Caronia electromagnetic phenomenon in Sicily and spherical UAPs. Since 2003 something very anomalous is occurring recurrently in Canneto di Caronia in Northern Sicily (Italy), in the province of Messina. Unexplained fires suddenly started to occur inside many houses of this small town, which is close to the sea. Many objects, such as blankets, armchairs, electric facilities, and other domestic devices were suddenly burnt inside the houses, without hitting the persons who inhabit them (Il Mistero di Caronia, website). Electromagnetic effects occurred to cell phones too, which spontaneously ringed or self-recharged. The phenomenon went on continuously for many months, and soon people started to see very often "spheres of light" too in the sky. An association of these light phenomena was soon made with the mysterious fires, whose cause was then "symptomatically"explained by military physicists of the Italian Navy as nano-pulse and high-intensity microwave beams (a technical report of the Government is not available yet to the public, at the present time). A witness attests that he saw and then photographed a military helicopter that was kind of "chased" by a sphere of light. Suddenly the helicopter was obliged to make an emergency landing due to an unexplained quite serious damage occurred at that time on one of the blades of its helix. One of the blades appeared to be "scorched" at some specific part of it. Technicians and scientists of both the military and geophysics institutes, after devoting a long time to the monitoring of the area, ascertained definitely that no geophysical cause was responsible for the global phenomenon seen very recurrently there. What is quite interesting in this case, apart from the general described context, is the fact that some damage was reported by a helicopter due allegedly to one of these spheres, which might be suspiciously associated with the reported and confirmed microwave pulses of beamed radiation.

1980), being the first mechanism active if the plasma is interacting very close to the medium, and the second active if the plasma is less close than in the first case. This is due to the decrease of temperature with distance. Of course such a physical behaviour can be deduced from optical spectra of the plasma sphere, in which a totally continuum spectrum shows a full ionization process, while a line spectrum shows an excitation process. The excitation process doesn't depend only on temperature but also on the excitation potential of the chemical elements interacting with this kind of plasma. Clearly thermal interaction will occur firstly with the surrounding atmospheric medium and occasionally with an aircraft, if this one is approached by this kind of UAP.

The physics of the problem can be in principle 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 that which the structure of a plasma spheroid is. Assuming that the plasma is represented by a high-temperature perfect gas having pressure $\boldsymbol{P}$, temperature $\boldsymbol{T}$, mass $\boldsymbol{M}$ and density $\boldsymbol{\rho}$, that the sphere containing it has a radius $\boldsymbol{r}$, 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:

$$\frac{dP(r)}{dr} = -\frac{\eta \cdot M \cdot \rho(r)}{r^n} \qquad \textit{Hydrostatic Equilibrium} \quad 2$$

Where $\boldsymbol{\eta}$ is a constant depending on the central force keeping all the particles together to be still defined (as we have no confirmation yet of the real mechanism, but we have only hypotheses on it), and $\boldsymbol{n}$ 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).

$$\frac{dL(r)}{dr} = 4\pi \cdot r^2 \cdot \rho(r) \cdot \varepsilon \qquad \textit{Energy Generation} \quad 3$$

Where $\boldsymbol{L}$ is the luminous energy of a plasma sphere characterized by a thermodynamic equilibrium between matter and radiation, and $\boldsymbol{\varepsilon}$ 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:

$$L_B = 4\pi \cdot r^2 \cdot \sigma \cdot T^4 \qquad \textit{Bolometric Luminosity} \quad 4$$

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

Assuming that the produced luminosity is related to Temperature, we also have:

$$\frac{dT}{dr} \propto -\frac{L}{\beta \cdot 4\pi \cdot r^2} \qquad \textit{Energy Transport} \quad 5$$

Where $\boldsymbol{\beta}$ 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 know yet the boundary and initial conditions with sufficient precision, which can be only so far arbitrary, 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 and witnessed facts concerning plasma spheres several reasons exist to suggest that plasma spheres are electrical/magnetic physical systems too. The inclusion of these parameters (we do not know yet how exactly) inside previous equations renders necessarily the problem quite complicated and the solution of a complete set of equations uneasy (but 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.

Finally a photo-ionization factor should be taken into account too, above all if the photons emitted by the plasma UAP are particular energetic, especially if they radiate in the ultraviolet too. In such a case we can define this quantity:

$$R_I = \left(\frac{3 \cdot N_*}{4\pi \cdot \gamma \cdot n_P{}^2} \right)^{\frac{1}{3}} \qquad \textit{Ionization Radius} \quad 6$$

Where $\boldsymbol{N_*}$ is the number of ionizing photons emitted in the time unit by the plasma sphere, $\boldsymbol{\gamma}$ is the recombination coefficient, and $\boldsymbol{n_P}$ is the number of atmospheric particles involved in the ionization process. Due to the spherical shape, this plasma object is expected to act isotropically, namely radiating in the same way in all directions.

What happens if such a plasma sphere approaches or impacts an aircraft? It is expected that thermal energy is immediately transferred (Lienhard, 2006) to it and that the produced damage to fuselage is proportional to the intrinsic energy density of the plasma sphere at the moment of approach/impact and its capability to be transferred to the aircraft. We expect that this may happen in several ways. If the sphere impacts the fuselage the energy can be transferred locally, in case producing strong heating. The produced effect should depend both on the time-scale with which such a thermal transfer occurs and on the total quantity of energy contained in this kind of plasma sphere. Let's now try to imagine several scenarios. For instance if the energy density is very high a short time-scale can be sufficient to cause a consistent damage. If the energy density is low but the structure of the plasma sphere is hydrostatically stable the time-scale with which the energy is transferred to the aircraft can be relatively long (if the plasma sphere remains close to the aircraft for a sufficiently long time) so that a damage may anyway occur. If the material of the fuselage is able to trigger a sudden modification into the plasma sphere once an impact occurs, it is expected that the energy may be transferred explosively, which normally occurs when the structure breaks on a time-scale that is much shorter than the capability of the plasma sphere to reset up its hydrostatic equilibrium. This manifests itself in form of a shock or blast wave (Book, 1994), causing possible serious local damages or destruction of the aircraft, according to the quantity of energy that has been liberated. If the explosion occurs in an adiabatic regime for the plasma sphere (characterized by no heat exchange with the environment outside of the sphere) a mechanical shock wave can develop by producing a consequent deflagration (with subsonic speed) or detonation (with supersonic speed). The problem can be treated using the hydrodynamic partial derivative differential equations, which describe simultaneously in time and space the trend of the involved thermodynamic flux variable of plasma ions after assuming precisely the way in which the density is distributed inside the plasma sphere, given by:

$$\frac{\partial V}{\partial t} + V \cdot \frac{\partial V}{\partial r} + \frac{1}{\rho} \cdot \frac{\partial P}{\partial r} = 0$$

(A) *Motion* 7

$$\frac{\partial \rho}{\partial t} + \rho \cdot \frac{\partial V}{\partial r} + v \frac{\partial \rho}{\partial r} + \frac{2\rho \cdot V}{r} = 0$$

(B) *Mass Conservation* 8

$$\frac{\partial P}{\partial t} + V \cdot \frac{\partial P}{\partial r} = \gamma \cdot P \cdot \left(\frac{dV}{dr} + \frac{2V}{r} \right)$$

(C) *Energy Conservation* 9

Where V, P and ρ are respectively the velocity, the pressure and the density of a perfect gas, r is a radial coordinate, t is the temporal coordinate and γ is the adiabatic coefficient.

If the explosion occurs in an isothermal regime for the plasma sphere the energy conservation equation becomes $dT / dr = 0$, remaining the others unvaried. In such a circumstance a "thermal wave" can be produced, where electrons move faster than ions (Lerche & Vasyliunas, 1976). According to the observed physical properties of Hessdalen-like spheres (Teodorani, 2004a), an isothermal regime for plasma spheres is the most probable scenario. In such a case the effect is expected to be mostly thermal and it can create a drastic overpressure generating the effect of a sort of thermobaric bomb. The damage to the airplane can be totally destructive as well.

A different scenario can be invoked if the plasma sphere enters inside cavities such air intakes: it can create a sudden overpressure inside, as the air can be all of a sudden heated due to the very small volume where this thermal change happens. If the liberated energy is strong enough this overpressure can convert itself into engine overheating or into mechanical destruction. If the plasma ball maintains a position close to one of the wings (or occasionally the tail, ailerons, winglets, flaps or canards) and for a sufficiently long time it can seriously cause an occasional pressure unbalancement on a side due to the sudden onset of a locally and transiently convective regime and affect the aircraft aerodynamic stability, so causing a possible stall and its consequences.

But 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 the interstellar space (Hiltner et al., 1962; Lang, 1998). Therefore the problem here might probably turn from hydrodynamics into magneto-hydrodynamics. The inclusion of a magnetic field means several important facts. Due to the existence of a factor given by “magnetic pressure” the dynamical properties of matter are influenced by this, in addition to mechanical pressure [4]. Let’s now consider a plasma 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 also 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, the angular velocity increases. This means that when a plasma sphere collapses for some reason the plasma starts 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) inside the plasma increase its temperature and consequently also its luminosity, so that we have a highly energetic plasma sphere that is suspiciously existing in a totally isothermal regime (constant temperature without adiabatic cooling via expansion).

If we assume that such a magnetized plasma sphere is already strongly collapsed when it approaches an aircraft, we might pose now a crucial question: what happens when the plasma sphere touches the fuselage of an aircraft? It is reasonably suspected that its equilibrium may be suddenly perturbed or totally broken by an impact, where presumably a sudden transfer of energy may occur to the fuselage. The liberation of this energy might be violent as the “magnetic cage” containing the plasma might be suddenly induced to a rupture of its magneto-hydrostatic equilibrium, maybe in a similar way as when a “magnetic cap” on a much larger scale such as the solar surface is suddenly broken in a region where a black spot is present (Thomas & Weiss, 2008) and where a sudden consequent flare-like eruption arises. The effect should be expected to be explosive due to the release of an enormous quantity of energy: maybe this would result into something that might be called a “magneto-thermal explosion”, namely: a thermal explosion enhanced by the sudden liberation of magnetic energy. Of course this is only a scenario, and these are only proposed ideas but it is important to fasten them once and for all, in order to carry out an in-depth quantitative subsequent study

[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 is the wavelength extent of such a splitting – quantitatively measured by a factor $\Delta\lambda$ (where λ is the wavelength) – and 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 optical spectroscopy: this measurement is absolute, regardless of the distance to the light source (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).

once the ideas are cleared and the physical problem is fixed and well posed in its completeness. There is no doubt, anyway, that the study of plasma spheres has a strong potential for fundamental physics and maybe also for possible technological applications. This possibly includes new kinds of weapons: military scientists are effectively working on something similar to that which has been exposed here (Hambling, 2009).

In the case of an allegedly artificial spherical UAP, so far we are prevented from depicting precise realistic scenarios, which should mainly depend on the way in which the alleged propulsion engine interacts with the mechanical structure of the craft and with its electrical and electronic systems. But we have so far no knowledge of this kind of propulsion system, and whatever description would be probably premature as it would be mainly based on speculative calculations of fringe physics (Hill, 1995; LaViolette, 2008). Nevertheless some happenings, which are only partly scientifically deduced, show that some "energy beams" are suspected to be produced sometimes by this kind of "probes" causing an immediate heating effect in the environment (Haselhoff, 2001, footnote 2). What we know so far is that the most probable energy source of such beams might be high intensity and very short duration microwave pulses having a more or less narrow bandwidth, or even monochromatic. A specific MASER source cannot be excluded in some cases. This kind of weapon is anyway not unknown to human technology (Kochems & Gudgel, 2006; US Air Forces, 2002) because it seems to be the most important mode studied (and possibly already employed) by the SDI (Space Defence Initiative). A system of this kind is expected to be much more efficacious in space where the total absence of atmospheric gas makes so that the energy of the beam maintains itself concentrated and focussed up to very long distances. This doesn't mean that such a system cannot work effectively also inside our own atmosphere if the beam is intended to be shot at relatively short distance, where, namely, the column density of the air is not sufficiently high to absorb consistently the energy of the beam. Of course, there are many suspicions that such kind of beam should not be aimed occasionally but rather intentionally exactly as a weapon system: therefore in addition to a microwave or MASER beam also some alternative kind of directed high energy (megawatt or more), such as LASER, might be suspected to be used (Kochems & Godgel, 2006). After all we humans are already able to experiment with a certain efficiency weapon systems such as the ABL (Airborne Laser) and the THEL (Tactical High Energy). Nevertheless we cannot a priori exclude that some of these beams (in particular microwaves) are non-intentional but rather the result of a propulsion system of some kind, something of which is currently experimented by human technology (Myrabo, 2006; NASA, 1999). Clearly most of that which has been discussed here is so far speculative. Nonetheless very precise real and spatially recurrent events and not-unreasonable possible connections between the production of high-energy radio emission and the sighting of spherical light phenomena (see footnote 2), should induce us to a certain attention and to the preliminary depiction of scenarios in order to prepare ourselves to a possible threat and to defend ourselves from it. Such a threat should not necessarily be of extraterrestrial nature (SETV, website; Teodorani, 2006); it might be a new kind of experimental human weapons (Hourcade, 2007; Teodorani, 2004b). These kinds of weapons are now a reality, even if we do not know yet precisely at which operational extent (in particular the maximum employed power) or diffusion in the world. Rather we do not know yet how an artificial spherical craft can levitate in the air without using any known conventional propulsion system [5], unless some already experimented electromagnetic propulsion system is already operational (Myrabo, 2006).

[5] Unmanned Aerial Vehicles. Many are the models of UAVs having a totally unconventional shape, such as disks, egg-shaped crafts, or something that is close to a sphere but not exactly that (Teodorani, 2009a). Some of these drones work thanks to an encapsulated helix inside them. [See 4.2 for further discussion and photographs. (Ed.)]

Finally, we might now turn back to the plasma sphere hypothesis for a simple reason. The reason is if naturally produced plasma spheres can produce beams of radiation. Witnesses do exist about this manifestation. How can this happen? We have not yet a definitive answer of it, of course. But this might be a stimulus to interrogate ourselves in order to trigger a possible physics within this possibility 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 to produce it is a mechanism to accelerate particles. This is also known in the macro-scales of Universe, such as in the case of active galactic nuclei or similar objects such as Quasars. These are an example of high-energy relativistic particle acceleration along magneto-channelled tubes called “jets” (Melia, 2009). This also happens in 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 on all scales: on Earth and in pulsars and even larger structures. Why not also in plasma spheres that is occasionally seen inside our atmosphere? (see Fig. 7).

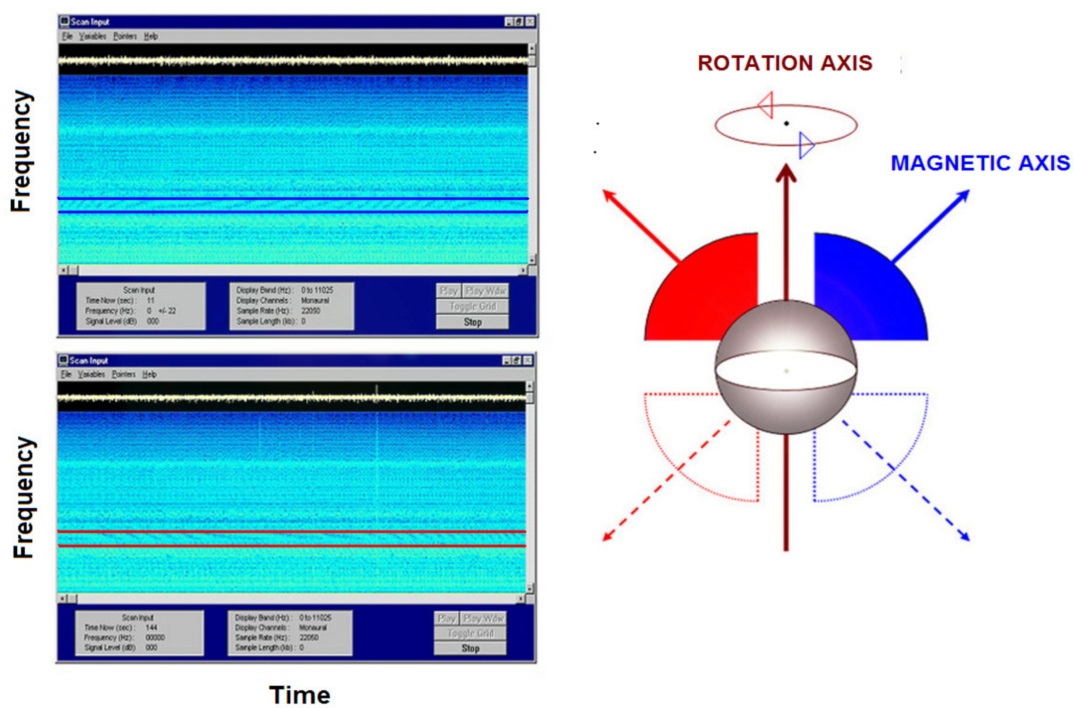

Figure 7. *Left*. VLF spectrograms (range: 1-3 KHz; frequency increases from down to up), showing a periodic Doppler effect with inversion from blue to red shift (velocity $V = c \cdot (\Delta\nu / \nu)$, where c = light velocity and ν = frequency) and characterized by a velocity ranging from 10 to 100.000 Km/sec. *Right*. Physical qualitative model showing a fast spinning obliquely rotating plasma sphere able to accelerate relativistic particles, where the beam periodically approaches and recedes from the observer.

It is not possible to exclude that a sort 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, 2004a, 2004b), including the one from spherical to cylindrical. This witnessed fact should make our neurons elaborate. 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 well know 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, even where we shouldn’t even expect, such as in the case of spherical UAPs.

Returning to the aviation safety issue, we should now ask ourselves how a beam of this kind can be dangerous to the flight conduct. In both cases – microwave and/or high-energy particles – when such a beam hits an aircraft it can clearly induce a very localized strong temperature increase in any aircraft fuselage by causing sudden heating followed by a partial (see footnote 2) or total mechanical destruction of the entire structure.

1. <u>Electrical energy</u>. Let’s now consider the two extreme alternatives considered above (plasma and artificial spherical UAPs) when electric energy is involved.

Let’s start with plasma spheres. First of all we should ask: how do they move in the air? Observations show often (but not always) sudden and sometimes zigzagging movements: this is not at all an aerodynamic motion. Avoiding speaking of exotic situations such as “antigravity”, let’s be more grounded and try to imagine how a plasma sphere can move in such an observed way. One possible way is based on electrostatics. It is in fact expected that such plasma spheres are electrostatically charged: therefore they naturally tend to be attracted by charges of opposite sign and repelled by charges of the same sign. According to some physical models the motion in the air of such plasma spheroids is caused by the escape of protons from the core: this occurrence triggers a residual negative charge in the core region and produces a consequent ionic current in the air (Fryberger, 1997). Many objects in nature can be electrically charged due to diverse reasons, especially some objects or vehicles that can acquire a charge after mechanical attrition with the air consequently to a motion, such as a car or even an airplane. Obviously an oppositely charged plasma ball tends naturally to be attracted by such moving devices, clearly not because it wants to chase them intentionally (as much of the UFO literature is interpreting) but because it is simply electrostatically attracted by them. This can depend on the strength of the charges in play and on the distance of mutually interacting objects. Therefore this so simple mechanism might explain the primary cause that makes an airplane or a car approached by plasma spheres; all the rest should be thermal-mechanical interaction. An electrostatic interaction with the electrical and electronic systems that guide the aircraft should be taken into account as a very basic and serious factor. For instance the “glass cockpit” systems characterizing the avionics of nowadays (Pallet, 1992) might be seriously vulnerable to such an occurrence and render the flight much more dangerous than in the case of avionic systems of the previous generations. This kind of interaction is expected to cause a black out and/or severe malfunctions of the electronics aboard (Haines & Weinstein, 2001), depending on the intensity of the electrostatic field and on the distance of its source from the aircraft. Typically computer-controlled devices, such as FBW (Fly-By-Wire) systems, would be affected by even more severe effects, just directly to the aerodynamic aspects of the flight due to the fact that all the aerodynamic devices of many airplanes (in particular the military ones) of today are controlled electronically by the FBW system. Moreover an electrostatic interaction might cause a severe disturbance to the communication systems of the aircraft and to the "data link" systems of a squadron of military aircrafts communicating together during a tactical and/or strategic operation. Is there any human "plasma weapon" aimed at blocking a joint military plan and action? If so, such a weapon might decide the result of an aeronautic battle (be it air-to-air or air-to-ground).

Finally, the attraction of a sphere of this kind to the oppositely charged fuselage of an aircraft might cause a more or less severe electrical discharge with consequences both to the electrical systems aboard and to the thermal-pressure equilibrium of an aircraft, which might also be burned locally or entirely according to the thermal energy liberated by such a discharge (if the airplane is not properly screened).

What about if the spheres are artificial and solid[6]? We cannot evaluate such a scenario because this would mainly depend on the propulsion system moving these alleged "probes". But also in this case an electrostatic interaction between two oppositely charged flying bodies (the sphere and the airplane) might be expected as well. Alternatively, possibly, some strong electrostatic field might be produced deliberately using an after-effect of the employed propulsion system.

1. Magnetic energy. – The movement of more typical plasma spheres may be determined by two factors: electrostatics and magnetism. The first case has been already discussed. Let's now consider the second. There are good reasons to suspect that these spheres might be induced to move along "magnetic rails" or to pass from a local magnetic line to another. This might be a typical example of interaction between electricity and magnetism. We have several sources of magnetism on Earth, the most important of which is given by the natural geomagnetic field and its disposition in specific magnetic lines along our planet. Overlapped with this we also have specifically circumscribed areas where magnetic anomalies are present. It is clearly expected that plasma spheres tend to have strong interactions here and/or that some areas of Earth can constitute a sort of "attraction poles" for this kind of phenomena. But natural magnetic geographic areas are not the only ones that must be considered. Human technology can produce devices that are themselves a source of magnetic and electromagnetic fields as well, wherever a production of electricity is operating. Possible examples to mention are many: electric and nuclear power plants, power lines, electric engines, and whatever is producing intense electricity. The cases of reported electricity blackouts in concomitance with UAP sightings are quite many, and we know that some of these unidentified aerial phenomena are just of spherical shape. It is immediate to imagine what can happen if these spheres interferes directly with the electric and local magnetic fields produced by airplane avionics (Haines & Weinstein, 2001), electronics and electrical engines therein. If a black out occurs in such a circumstance the possibility to turn off an engine (which nowadays is totally electrically controlled) is not certainly impossible, and this, obviously, can be extremely dangerous to the flight conduct. Similar interactions might occur also if the flying spheres

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[6] Solid-like plasma spheres. Are we exactly sure that a plasma ball should be necessarily only a bright one? This surely depends on its temperature, and, consequently, according to the *Wien law* given by $\lambda_{max} \cdot T = K$ (λ_{max} and **T** are respectively the peak wavelength and the temperature of a black body, and K a constant), as in the case of stars, plasmas can acquire a wide range of temperatures. If temperature is low we have a so called "low-energy plasma" whose luminosity may appear lower or much lower than the sky background at daytime. When the contrast between the plasma and the background is high and if the dynamic range of used sensors to record this is high as well, it is possible to impress on CCD sensors "dark objects" that look "solid" but that are not. This kind of objects can be reasonably detected mostly in the infrared. In fact some anomalous spherical objects have been detected indeed by using infrared methods (Avila, 2006).

are artificial probes, but, as in previous cases, we have no elements to speculate because we know almost nothing of their propulsion mechanism.

2. Radar emission.[7] – As we all know, the emission of radar waves is of quite high energy. Radars are able to track not only solid objects but also clouds and electrical atmospheric activity (meteo radars). Therefore also plasma objects such as plasma spheres can be included into the possible tracks. The point to be made here is not just how strong is the radar signature produced by such aerial phenomena but how and how much radar waves (in particular, high radio frequencies, such as microwaves emitted by pulse-Doppler radars) can interfere with plasma spheres. Injection of energy is expected to occur into the plasma and a possible "feeding process" cannot be in principle excluded, in the light of the repeatedly experimented laboratory tests where the emission of microwave pulses in particular conditions of humid air is able create for a few seconds little plasma spheres similar to ball lightning (Ohtsuki & Ofuruton, 1991; Teodorani & Strand, 1998; Teodorani, 2008). A logical question clearly arises now: what happens when radar energy is injected into a plasma sphere that is already formed, while it is approaching an airplane? What is suspected here is that, in addition to the possibility of radar wave reflections, a microwave energy transfer to the plasma might be expected, so that the plasma sphere might change its energy regime, which, in its turn, might constitute an increased danger factor if this happens when such a plasma object approaches an airplane. The probability that this happens is clearly increased if the plasma target is not simply periodically radar-scanned but rather locked-on continuously: a situation of this kind should be found mostly in the case of high-performance military aircrafts. Many airplanes – both military and civil – are equipped with radars of very high power, in particular heavy interceptors (such as Lockheed-Boeing F-22, Sukhoi Su-35, Eurofighter Typhoon, Dassault Rafale, McDonnel-Douglas F-15, Mikoyan Mig-31, just to cite some examples: Teodorani, 2009a). None knows yet what may happen when/if a plasma sphere is "enhanced" by radar emission: it may be suspected that, in particular situations on the pathway, a possible enhanced interaction with the airplane might increase in several ways. This possibility should be explored by physics computer-simulation.

If the interaction occurs with a spherical probe, it cannot be excluded that radar scanning, at particular circumstances, may interfere with the guidance system of the probe itself, in case altering its regime of motion and creating possibly uncontrolled situations that might constitute a danger both to the airplane that is a source of radar emission and to whatever is on the ground.

3. Radioactivity emission. – According to some more or less canonical theoretical models, some plasma spheres can be the source of radioactivity (alpha, beta, gamma particles) and of the deposition of neutrons (Fryberger, 1997). According to other physical models of ball lightning kind some of these spheres can be also the source of the production of nuclear fusion (Stenhoff, 1999). This means that another source of possible danger can arise, not only when such phenomena approach airplanes but also when they approach whatever area inhabited by humans. Anyway, concerning strictly aviation this possibility, if true, can be dangerous when such spheres approach civil airplanes, which are normally full of passengers. Therefore this is a kind of damage that can affect much more living creatures than technological equipment.

4. VLF-ELF electromagnetic emission. – Some plasma spheres may be associated with the emission of very low or extra low frequency (Strand, website; Teodorani, 2008). This can

[7] See 2.3 in this regard as well (Ed.)

mainly interfere with military submarine communications and/or VLF-ELF transmitting stations, which might be more or less seriously disturbed.

According to a physical theory concerning plasma ball formation very low-frequency waves – in case generated by a previously existing plasma ball, or by other natural causes coming from the ionosphere – if associated to high-frequency waves (such as microwaves by radar, as an hypothetical instance) may cause the formation of plasma vortexes in the air (Zou, 1995), whose behaviour is not possible to predict but which might constitute some danger to the conduct of any flight. It is not expected in general that very low-energy electromagnetic emission alone is able to affect the electronics aboard airplanes. What is important to consider here is that, according to the specific frequency range, it can interfere directly with brainwaves of the pilots and of passengers and cause often altered consciousness states and severe hallucinations. Of course this effect might render the conduct of any flight extremely dangerous. The physiologic effect of these waves, also in connection with pulsed magnetic fields, is now well known and demonstrated in biophysical and neurophysiologic laboratories (Persinger, 2000).

Other possible kinds of more exotic (Teodorani & Strand, 1998) potential interferences with aviation safety that might be due to relativistic and/or "macro- quantum" effects of the light spheres under study, or to more unconventional hypothesized effects such as "anti-plasma", anti-matter, dark matter, negative energy, mini-black holes, magnetic monopoles, ether vortexes, micro-storms, circular electric currents and many others (more or less rationally grounded) are out of the pragmatic scopes of this dissertation, within which only conventional (and, therefore, having a more easily and concretely measurable physics) mechanisms are intended to be suggested here in the perspective of a in-depth study to be done in the near future according to the ascertained level of our knowledge of physics and to its experimental feasibility.

As it can be seen, all the possible scenarios (which are probably only a small part of all the other possibilities) that have been exposed and ventured here cannot be so far quantified because still now we do not know sufficiently well and completely the boundary conditions of the physical problem related to plasma spheres. It is by my opinion quite so far premature to venture calculations and/or numerical models when the map and the territory cannot yet be matched together in a proper way. The ideas proposed here are just born from certain knowledge of some observed facts concerning mostly plasma spheres and not from a definitive theory explaining them in form of a "unified theory", which doesn't exist yet but must be still deeply explored. Existing work hypotheses, even of quantitative kind, are not enough to give us the true *numbers* of the entire problem. To do this we need to construct true theories, which are the result of a perfect match with instrumental observations. Moreover it is out of the scope of this essay quantifying exactly the level of the possible threat that such phenomena might represent to us and to aviation in particular, but I think that it is already possible to "qualify" the problem that is investigated now, in order to trigger possible scientific debates, and, in some cases, the preparation of possible preliminary multi-parametric numerical modelling and laboratory simulation, to be done in a subsequent phase.

In order to explain better this phenomenology we do need to have a much better scientific experimental knowledge of the investigated phenomenon, which so far is quite limited to a few somewhat established observational facts and to quite many testimonial cases. In some (very few) cases it has been possible to describe quite accurately the purely observational behaviour of plasma spheres such as "earthlights" (Teodorani, 2004a): this is a quite technical description in the same way as astronomy is able to describe accurately celestial objects and stellar aggregates, but this is not the same as when astrophysics explains the physics of what is technically observed using very specific models involving many aspects of physics that are interconnected together. We do need many more data before venturing a real attempt of construction of a physical model, which, as we know, can be considered a *model* only if theory and observation match together very well and when the number of hypotheses is reduced consistently. This is, I think, scientific realism concerning the investigated problem and it is obviously moved by a need of true rigour and completeness in attaching this problem, which can be achieved only if the mathematics describing it is strictly pertaining to the effectively observed reality.

3 – How Can This Research Improve?

What do we need in order to transform that which is occasionally technically observed and measured into really self-consistent physical theories that can permit the realistic construction of numerical models simulating how exactly plasma spheres can constitute a threat to aviation? We do need to use systematically the appropriate measurement instrumentation, which must be precise, complete and of extremely practical use. Obviously the ideal instrumentation platform should be of opto-electronic kind (Wilson & Hawkes, 1997), namely very similar to that which is used in the military as an adaptation only aimed at measurement sensors. But achieving this is not very realistic (even if highly desirable) because of the high number of opto-electronic stations that it would be necessary to deploy in areas where such phenomena occur more often, due to the prohibitive cost of a single station that should be opportunely custom-built for this kind of operation, and due to the necessary funding for highly specialized personnel able to manage this kind of equipment. But we urgently do need to improve the incomplete picture that we have at our disposal concerning the so called “spheres of light”, and the only way to do this is twofold: 1) accurately processing statistically selected testimonial cases (physics of ball lightning is mostly based on this procedure due to the lack of true measurements: Stenhoff, 1999); 2) measuring directly the phenomenon, using multi-wavelength and multi-mode instrumentation, where such a phenomenon is geographically recurrent and/or occurring through “temporal flaps” of limited duration.

The first procedure is being accomplished by serious investigators, but the number of screened cases should be expanded in order to build up a better statistical picture, namely: the more are the cases that present the same behaviour and the smaller is the error box that physical models have to consider in a subsequent phase. The second procedure has been done only occasionally; data obtained in this way are much more precise than witness data, but the statistical sample is still too poor in order to minimize the error box that must be adopted by theoretical models when they try to simulate the observed behaviour. Moreover, this second procedure is still incomplete or lacking in terms of simultaneity of multi-wavelength measurements and in terms of sophistication of the used instrumentation. This happens due to the globally elusive nature of such phenomena, which of course are not repeatable at will, so that a fully scientific treatment of this problem is still extremely difficult. For all of these reasons this author has very recently proposed – as a scientific consultant of a Parliamentary Interrogation on “UAP” – to create a centralized organization in Europe that is able to coordinate efficiently all of this information and to deploy in useful time all the necessary off-the shelf measurement instruments whenever a flap of UAPs (of any kind) occurs everywhere in Europe or, in case, also out of it.

Now, after presenting the most important effects that such spherical aerial objects may cause on aviation it is necessary to optimize the measurement procedures (Sturrock, 1998; Teodorani & Strand, 1998; Teodorani, 2000, 2001) that can help scientists to build up solid physical models that are based on the observed reality and not only on reasonable physical conjectures on what the reality might be. Many more data are necessary in order to construct a real physics on this kind of phenomena: this is the only procedure to protect aviation, our technological devices and we from possible dangers caused by these phenomena. So, what should be now the next step to improve our scientific knowledge in this specific topic? This step must be both strategic and tactical. A proposal for this might be done through the following points:

a. Optimization of Strategy and Methodology. – First of all a basic methodological factor must be once and for all established. The idea is to deploy off-the-shelf measurement instruments to areas where the phenomenon is recurrent since a long time and/or where/when the phenomenon suddenly manifests itself in specific areas in the form of so called "flaps". More than one observation group is expected to monitor the phenomenon using the same instruments and the same procedures, on which a previous inter-subjective consensus has been reached. The data that have been acquired by all the groups must be confronted together. A confrontation of the data obtained by different observers concerning the same targeted objects creates inevitably a methodological condition of "repeatability". In such a way the error with which measurements are done can be minimized, while the factor given by subjectivity is avoided. Therefore a new consensus – obtained by using subsequent approximations – can be reached and the science that can come out from all of this is stronger and more reliable.

b. Optimization of Portable Measurement Instruments. – The instruments are the best ways to improve our scientific knowledge on this kind of anomaly, just like for any other kind of radiant source (Hiltner et al. 1962). Due to the peculiar nature of the phenomenon and its sudden apparition in the form of flaps, the equipment must be extremely practical and portable. Specific kits or small containers keeping inside all that which is necessary should be put at the disposal of several research groups composed of physicists of several branches, engineers and informaticians. Every group should contain all these professional figures. At the same time a new profile of "ufologist" should be created, namely a figure that is able to integrate logically and rigorously all the acquired knowledge. The ideal instrumental kit should contain inside: 1) high-resolution reflex digital camera equipped with a custom-built dispersion grating for spectroscopy; 2) professional portable videocamera; 3) altazimutal mounted portable telescope (of the class of 200 mm aperture) connected to a CCD camera (Stephan et al., 2009) for acquiring both photometric and spectroscopic data, and to a specific CCD camera for target tracking (using specific software); 4) infrared thermocamera equipped with a 30-300 mm zoom lens; 5) ultraviolet detector; 6) computer-controlled VLF-ELF receiver/spectrometer; 7) computer-controlled microwave spectrometer; 8) computer-controlled digital magnetometer; 9) spectroradiometer or photomultiplier; 10) digital radioactivity detector; 11) digital ultrasound detector; 12) electrostatic detector and voltmeter; 13) computer-controlled EEG (Electro Encephalograph); 14) high-power (of the class of 300-600 mW) Laser for testing the target (Teodorani & Strand, 1998; Teodorani, 2000); 15) radio scanner to monitor the passage of airplanes; 16) night vision goggles or image intensifier; 17) Laser range finder; 18) theodolite or data scope; 19) weather station. These instruments are intended to be used simultaneously so that a multi-wavelength and multi-mode picture of the phenomenon can be obtained, together with the possibility to measure the time variability of all physical parameters (Teodorani, 2000).

c. Optimization of Fixed Stations. – Only the areas where the phenomenon is established to be recurrent since a long time should be covered by one or two permanent automatic observing stations similar (but more complete) to the Hessdalen one (Strand, website; ICPH, website), which must be equipped with one high-sensitivity CCD zoom camera for imaging and one high-sensitivity zoom camera for low-medium resolution optical spectroscopy (using a dispersion grating), a VLF-ELF receiver, a radar and a magnetometer. All the stations, which should be standardized both with the used instruments and with the used software to control them, should be linked together wherever they are deployed in the world.

d. <u>Optimization of Data Taken by Military Pilots</u>. – Military pilots use aircrafts that are often equipped with sensors that can be potentially and occasionally used also for scientific scopes, in particular high power/sensitivity multi-target radars and Forward Looking Infrared Radar (FLIR). Military pilots, who are often called on scramble also for identifying this kind of targets, should deliver the recorded data, including the registrations obtained through Head Up Displays (HUD), to the scientists who are studying this problem. At the same time scientists would commit themselves to maintain secrecy whenever it is necessary and to release to the public only what they are allowed to do for reasons of public safety. Military data can reveal themselves to be extremely precious for these scientific goals. In particular radar data, once accurately recorded, can permit to reconstruct all the kinematics of the aerial anomalies (Meessen, 1999, 2000).

e. <u>Optimization of Data Collected by Civil Pilots</u>. – Civil pilots use aircrafts that are normally equipped with radar and more recently also with HUDs. All the data can be recorded and therefore, as in the previous case, these data can be potentially delivered to researchers for a scientific study. A correlation of the flight data at the time of an approach by UAPs (spherical ones in particular) and of the radar data obtained of UAPs might furnish very important scientific information.

f. <u>Optimization of Data Collected by Control Towers</u>. – Radar operators, especially from military bases, can acquire extremely interesting data concerning this kind of UAPs. In particular they can record simultaneously radar tracks of both a UAP and the airplane that it occasionally approaches. The dynamics of these possibly mutually interacting objects can be studied very carefully by radar tracks from ground control, and in case also by AWACS (Airborne Warning and Control System) and ELINT (Electronic Signals INTelligence) flying platforms. At the same time the civil or military pilot that is occasionally chased by a UAP can collaborate in furnishing numerical information that integrates the one obtained by ground and aerial radar stations.

g. <u>Optimization of Data Collected by Astronauts and Cosmonauts</u>. – The ISS space station is equipped with all sorts of scientific instruments aboard, which are partly permanent and partly variable according to the scientific payloads that are planned in the course of specific missions. Some of these instruments might furnish very important scientific data on spherical UAPs. Astronauts and cosmonauts should be prepared to this possibility since before their departure and accurately trained to face the possibility that their craft or the space station where they work can be approached by anomalous aerial phenomena. Reports of videos of "spheres of light" are not uncommon from space and some scientific analysis already exists (Carlotto, 1995; Kasher, 1995). An accurate scientific study of these data from space can permit to ascertain if such anomalies are of plasma, artificial, meteoric, cometary, or of more prosaic nature. These data should be shared with scientists on Earth, so that a cross confrontation of the data is possible and consequently a better science is done.

h. <u>Optimization of the Information Obtained by Visual Witnesses</u>. – Most of the times UAPs, and in particular light spheres, are seen by occasional witnesses on ground, who can only tell a story but, as it is well known, they cannot take scientific or documentary data (except maybe in the cases in which photos and/or videos are obtained). The information that witnesses can furnish might reveal itself to be very reliable if this information is accurately screened by experts (such as astronomers, meteorologists, geophysicists, engineers, psychologists and serious ufologists). In such a way, if more witnesses of the same UAP are available, it is possible to obtain scientific information that is accurately weighed by a statistical analysis.

All of such optimization strategies and tactics, in particular the way in which an efficient organization and coordination should be established, once integrated together are the only key to obtain true science concerning spherical UAPs and plasma spheres in particular. A more accurate science means in this specific case more safety in the space environment and in all the situations involving military and civil aviation. So, what is the physical information that is needed to be obtained in order to expand and improve both qualitatively and quantitatively our scientific knowledge on spherical UAPs and in order to improve our safety when we fly? An essential idea of this is schematically presented in Table 1.

SCIENTIFIC INFORMATION	**USED INSTRUMENTS**
support to target sighting	night goggles, image intensifier
target position	radar, theodolite, data scope
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
interference with brainwave	portable EEG
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

Table 1. List of Information and Instrumentation Needed to Advance our Knowledge of Spherical UAP.

The subsequent step consists in analyzing the data using the most sophisticated software available. The final step is entirely dedicated to the construction of quantitative physical models and numerical simulations. Once we have a self-consistent model in hands we might also predict the behaviour of spherical UAPs, so that they would be really under a form of control from us. A further step might consist in trying to reproduce in a laboratory the observed phenomenon if it is really characterized by a plasma nature. Alternatively if the spherical object is of technological nature, we might try to build a similar one using a sort of reverse engineering, without any need of capturing one but only basing our deductions on the physical data that have been previously acquired in distance.

Conclusion

Unidentified anomalous phenomena of spherical shape are increasingly reported in many areas of the world. Most of them seem to be a plasma anomaly of nature, some others look something artificial. The dilemma is to know if they are two separate kinds of phenomena or if they are two different manifestation of the same phenomenon. In both cases we have a precious opportunity to expand our scientific knowledge. I think that what has been described and discussed in this essay represents the only really viable method to obtain data of importance for the physics of the investigated problem. A better scientific knowledge of the phenomenology can result to be a better protection from possible threats that might involve people, our technological devices and aviation and space in particular.

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