

CONTENTS

	Para	Page
INTRODUCTION		
Target Signature Control	1	A-2
SPHERICAL FORMATIONS IN THE ATMOSPHERE	7	A-3
Proposed Theory	12	A-5
Corona Discharge	13	A-6
Shells	14	A-6
SUMMARY	16	A-6

the plasma mass is capable of autonomous existence for an anomalously long time; when compared with an ideal plasma. The charged particle density for 100⁰ EPF may be of the order $5 \times 10^{16} \text{ cm}^{-3}$. The references indicate that at least 20-30 Russian scientists have been pursuing plasma research, its relevance to military activities, including ball lightning, and plasma research relative to air vehicles.(R)

6. In summary, the plasma density is such that, if formed (by whatever means) in the atmosphere, it is likely to:

- 'Float' or 'bob' (because of its close relative density to the surrounding air).
- Climb or descend slowly, unless acted upon by very strong external, potential differences seen in the 'darting' towards objects of different potential - often electrical or other earthed pylons, or their insulated or isolated conductors; or towards vehicles in open ground, especially on exposed high moorland or, for example, on mountain roads.
- Exhibit erratic motion caused by an interaction of total body charge with other surrounding magnetic and electrical fields.
- Be attracted towards areas where the electrical activity in the form of electrostatic charges may be modified by the presence of intense air-vehicle activity.

(U)

SPHERICAL FORMATIONS IN THE ATMOSPHERE

7. A 1995 Russian review states that spherical formations in the atmosphere originate mostly as a result of human activities. Examples of activities which can produce spherical shapes are:

- Launches of missiles, spacecraft and satellites.
- The burning up of used missile stages and defunct satellites in dense layers of the atmosphere.
- Atmospheric pollution (see also Working Paper 1 & 2 on Dusty Plasmas).
- The launching of stratostats and balloons (see Working Papers No.14 & 15)

8. Other spherical formations may be related to meteors, planets, the Aurora Borealis or other optical and natural weather phenomena, also covered in Volume 2. Many drifting luminous formations maintain their shape over long periods. Explanations have been sought, which include, chemical, optical and vortice models - which often do not explain the reported electrical properties of the formations. In contrast, the plasma models appear not to explain their stability and lifetime. At least one option[3] contends that such formations, including ball lightning, consist of electrostatically bipolar charged shells comprising orderly orientated water molecules.(U)

9. While ball lightning diameters (see Working Paper No.2) are predominantly small, by comparison with many others reported, the common factors between all these are that they exhibit:

- Sudden appearance/emergence.
- Sudden disappearance.
- Erratic and other motion which enables them to be clearly distinguished from familiar objects.
- Forms of energy detectable - electrical field(s) present, magnetic field(s) present, heat, light, colours and sound.
- Similar shapes or shapes and, in general, those formed by rotations or distortions of a sphere.
- Shapes described as patterns by that bounded by several 'marker lights' (or colours) - (e.g. rings of lights, triangles, oblongs).
- Shapes described as solid objects but often with lights (colours) at their sharp extremities, (is at their 'corners').
- A propensity for spherical formations to form near sources of Methane, Iron and copper.

(U)

10. About 60% of ball lightning phenomena have a diameter of ~5m, with a probability of occurrence of 10^9 to $10^8 \text{ km}^{-2} \text{ min}^{-1}$. In basic terms this is approximately 100 to 1000 incidents on earth every hour, many of which go unseen and therefore unreported. Apart from any visual sightings, the implication must be that these do not constantly present false alarms to radars. While the **theoretical** radar cross-section of the ideal reflective sphere, (given by $2\pi a^2$, where 'a' is the radius), can be 50 square metres for a 5m diameter ball and ten for a 1m diameter ball, at D(L) Band; clearly this is not the case in practice. Plasma researchers quote diameters from centimetres to 10-15metres and RCS values from -60dB to 8 metres at the same RF. (U)

11. During the period of observation the phenomena may exhibit one or more of the following:

- Gradual growth.
- Splitting into two or more separate parts (but rarely more than five), accompanied sometimes by a change of pattern, spacing and shape.
- Dissolution/dissipation to invisibility (often instability reported as accelerating away rapidly; when in fact the diameter reduces and intensity fades).
- Merging of disparate 'bright lights' (or colours) into larger formation (often reported as small craft joining the 'mother ship' and thereafter forming a row of portholes!).

- Disappearance, accompanied by smell.
 - Rotation, non linear motion.
 - Weak thermal radiation.
 - Translucence, haloes, blackness.
 - Beamed light emissions, especially when near a conductive object (usually described by witnesses as beams, which, if they move or rotate become 'scanning searchlights', or 'beams searching for a landing site', especially if the formation is stationary at the time. It is, of course, inevitable that conductive objects will be found - depending on the location. A vehicle, for example, crossing moorland, may be the only conductive object for miles apart from a few telephone or power wires). They are, most likely, the discharge or leakage paths by which the plasma entity gradually loses its structure and weakens to a point of disappearance unless it is either attracted away or its buoyancy state changes, allowing it to 'float off' and seek another destination.
 - Under some conditions invisibility to the human eye, while being visible to some forms of photography and contrarily, visible to the eye, but not seen on photographs taken at the time.
- or
- White ball lightning (generally smaller in diameter) is usually spherical, hence the name; larger formations with other shapes are often reported as discoids, and have often three or four different colours, especially at the top or bottom.

(U)

12 Proposed Theory It is noted that the Russian perception is much the same as in The West. That there is a UAP connection is evident by the 'beamed light emissions' and 'landing site' mentioned above. In a strong electric (E) field, a stable structure can be formed of water molecules, where their dipole moment vectors are aligned with the force lines. This is possible because they possess polarity and hydrogen bonds are capable of forming dense structures like ice or loose ones like snow. Among all known substances, water possesses the largest number of crystalline phases; which can be formed under various temperatures, pressures and water vapour condensation conditions. Certain types of ice, which originate at high pressure, can exist at temperatures exceeding 70°C. Only common ice is lighter than water. Due to ordered structures and high electric striction pressure, spherical formation balls can exist at high temperatures. Using the theory suggested [at Ref. 3], the shell stability and shell strength is determined by the local field, which keeps the shell of the spheroid in tension. The shell theory suggests that for such spherical formations, for example for a radius of ~10km, the delay period could be ~200s. When such shells disintegrate, molecules change state and stored energy is suddenly released, for example as a small explosion. The attractive force between a sphere and a conductive surface at distance ℓ , when the axis of the sphere is normal to the surface is given by:

$$F = 3p^2/32\pi\ell^4 \text{ at } p = 4\pi ER^3$$

At $R_2 = 10\text{m}$ (where R_2 is the sphere outer radius)

$$\begin{aligned} E_1 &= 3\text{MV.m}^{-1} \\ \ell &= 42\text{m} \\ F &= 123\text{N} \\ \text{or at } \ell &= 10\text{m} \\ F &= 40\text{kN} \end{aligned}$$

The magnitude of this attraction force, plus their low aerodynamic drag could explain how plasma balls have been seen to move against the wind. (U)

13. **Corona Discharge** The corona discharge from the surface of objects can ensure the stability of low density objects in the air. When the charged formation approaches a conducting object, the discharge of a bi-polarly charged shell would increase. This is normally accompanied by an electric wind which, in laboratory conditions can be shown to exceed 2m.s^{-1} . The reactive effect produced by the electric wind is capable of balancing the mirror reflection and gravitation forces. (U)

14. **Shells** Spherical formations are shells that may be perceived differently by the eye, cameras, or radar. These shells cause an interference of light and radio waves. Ambient light falling on a thin shell will be partly reflected by the inner and partly by the outer surface. If the shell thickness happens to displace a light source by half a wavelength the waves would interfere, thus making the shell appear as a black (or solid) object or silhouette. (U)

15. Supercooled water vapour in the discharge space can enhance the amount of glow by up to 1000 times. In the UAP context, eyewitnesses frequently report convergent radiating star-shaped beams. (U)

SUMMARY

16. The foregoing theory cannot be entirely proved to be an exact model of a UAP, but the characteristics are strikingly similar, if not identical to many of the reports on the UK database. Undoubtedly, the postulated shells can be stable, can travel, have persistence and other UAP-like characteristics. S.27

[1] "Study of Plasma Formations in an Erosion Discharge"
Avramenko R. F., Bakhtin B.I. et al Sov. Tech Phys 35 (12) Dec 1990

[2] Kang W.I., Radar M & Alexoff. I "A Conceptual Study of Stealth Plasma Antenna" Plasma Science Laboratory, University of Tennessee

[3] A.I Mesenyashin "Spherical Formations in the Atmosphere as a Physical Phenomenon" Journal of Electrostatics No. 36,1995. Russian interest in UAPs is often evident in this short review, where 'shapes as solid objects' and triangles etc are mentioned. The similarity of UAP characteristics are not normally connected in Western scientific papers on ball or bead lightning.

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