FIGURE 1: HIGH INCIDENCE UAP LOCATIONS (J. RANDLES)

		area in km²	population census 1991
Avon	Bristol	1,346	920,000
Bedfordshire	Bedford	1,235	514,000
Berkshire	Reading	1,259	717,000
Buckinghamshire	Aylesbury	1,883	620,000
Cambridgeshire	Cambridge	3,409	641,000
Cheshire	Chester	2,329	937,000
Cleveland	Middlesbrough	583	541,000
Cornwall	Truro	3,564	469,000
Cumbria	Carlisle	6,810	487,000
Derbyshire	Matlock	2,631	915,000
Devon	Exeter	6,711	998,000
Dorset	Dorchester	2,654	645,000
Durham	Durham	2,436	590,000
East Sussex	Lewes	1,795	671,000
Essex	Chelmsford	3,672	1,496,000
Gloucestershire	Gloucester	2,643	521,000
Greater London	London	1,579	6,378,000
Greater Manchester	Manchester	1,287	2,456,000
Hampshire	Winchester	3,777	1,512,000
Hereford & Worchester	Worchester	3,927	668,000
Hertfordshire	Hertford	1,634	952,000
Humberside	Hull	3,512	835,000
Isle of Wight	Newport	381	127,000
Kent	Maidstone	3,731	1,485,000
Lancashire	Preston	3,064	1,365,000
Leicestershire	Leicester	2,553	861,000
Lincolnshire	Lincoln	5,915	574,000
Merseyside	Liverpool	652	1,377,000
Norfolk	Norwich	5,368	736,000
Northamptonshire	Northampton	2,367	573,000
Tyne & Wear	Newcastle	5,032	301,000

TABLE 1(A): POPULATION DISTRIBUTION UKADR

/Cont'd......

Southend on Sea	153,700
Peterborough	148,800
Blackpool	144,500
Colchester	141,100
Brighton	133,400
Blackburn	132,800
Poole	130,900
Newport	129,900
Preston	126,200
Reading	122,600
Torbay (Torquay)	122,500
Saint Albans	122,400
Norwich	121,100
Ipswich	115,500
Oxford	109,000
Exeter	101,100
York	100,600

North Yorkshire	Northallerton	8,309	699,000
Nottinghamshire	Nottingham	2,164	981,000
Oxfordshire	Oxford	2,608	554,000
Shropshire	Shrewsbury	3,490	402,000
Somerset	Taunton	3,451	459,000
South Yorkshire	Barnsley	1,560	1,249,000
Staffordshire	Stafford	2,716	1,020,000
Suffolk	Ipswich	3,797	630,000
Surrey	Kingston	1,679	998,000
Tyne and Wear	Newcastle	540	1,087,000
Warwickshire	Warwick	1,981	477,000
West Midlands	Birmingham	899	2,499,000
West Sussex	Chichester	1,989	693,000
West Yorkshire	Wakefield	2,039	1,985,000
Wiltshire	Trowbridge	3,480	553,000
Total England	London	130,439	46,168,000

Cont'd.....

cities	population 1991
London	6,803,100
Birmingham	934,900
Leeds	674,400
Glasgow	654,542
Sheffield	500,500
Bradford	449,100
Liverpool	448,300
Manchester	432,600
Edinburgh	421,213
Bristol	370,300
Huddersfield	367,600
Dudley	300,400
Coventry	292,600
Sunderland	286,800
Belfast	279,237
Cardiff	272,600
Leicester	270,600
Newcastle	263,000
Nottingham	261,500
Walsall	255,600
Bolton	253,300
Kingston upon Hull	252,200
Rotherham	247,100
Stoke on Trent	244,800
Wolverhampton	239,800
Plymouth	238,800
Derby	214,000
Aberdeen	201,099
Southampton	194,400
Swansea	182,100
Northampton	178,200
Saint Helens	175,300
Portsmouth	174,700
Luton	167,300
Dundee	165,548
Bournemouth	154,400

Cont'd......

Borders	Newtown St.Boswells	4,698	103,000
Central	Stirling	2,700	268,000
Dumfries and Galloway	Dumfries	6,425	147,000
Fife	Glenrothes	1,319	339,000
Grampian	Aberdeen	8,752	493,000
Highland	Inverness	26,137	209,000
Lothian	Edinburgh	1,770	724,000
Strathclyde	Glasgow	13,773	2,218,000
Tayside	Dundee	7,643	385,000
Island Areas	-	5,566	71,000
Total Scotland	Edinburgh	78,783	4,957,000

WORKING PAPER NO. 4

AFTER-IMAGES AS A RESULT OF FLASHES OF LIGHT

February 1, 2000

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AFTER-IMAGES AS A RESULT OF FLASHES OF LIGHT

BACKGROUND

1. Illusions observed in darkness or low light conditions, after exposure of one or more eyes to a bright light are known as 'positive after-images' and are often similar in colour to the inducing light. Those illusions seen in moderate illumination are called 'negative after images' and are often of the approximation to complementary colours. In practice the actual appearance of after-images is complex and likely to depend on many factors. However, adaptation from dark to light takes much less time than from light to dark - hence there is an awareness of the appearance of a light in dark conditions much more quickly than the appearance of a shadow in lighter conditions. Excessive eye stimulation, as is well known, produces blindness in the limit.

2. Within the eye the sequence of changes which occur in reception after light is absorbed differs between rods and cones, classes of cones, and suffers further adaptation by the nerve cells of the retina and of the brain. However, the result is the persistence of the sensation of light after the stimulus has been removed.

3. **Primary Sensation** Human eye response is from $\lambda = 0.4$ to $\lambda = 0.7\mu m$ with an unaided peak at $0.55\mu m$; and a detectability from 10^{-6} cd.m^{-2} to 5000 cd.m^{-2}. There is a range of conditions over which the primary sensation produced by a flash of light depends on its luminance-time product (i.e. in general, the integration of luminance with respect to time). This is independent of temporal distribution. This was proved experimentally by regularly repeated flashes as long as 150 years ago and confirmed this century using extremely short flash durations now possible. The practice holds for flash values down to ~ $4x10^{-7}$sec and is considered valid for high intensities. For longer duration flashes the measurements are less researched. Hence, the integration of flashes is less reliable as a guide at an illumination intensity of 0.5cd.m^{-2} at which pulse durations of 27 millisec may be the eye integration limit (3° fovea fov). The time duration may be greater than 27 millisec for dimmer flashes and shorter in period for those which are brighter.

4. **Results of Experiments** Preliminary experiments [1] to investigate after-image conditions for eye stimuli of different lengths produced the following results:

- Stimuli ~2 sec maximum. The whole course of the (positive or negative) after image, excluding its first 15 sec, was dependent on total light in the stimulus and not on the light's intensity distribution in time.
- Stimuli 2-5 sec. The result only differed slightly from the 2 sec stimuli length above, but with some time distribution differences. In particular, there were some differences between positive (dark background) and negative (bright background) after-images.
- In the after-image observation time $t=10$ to $t=30$ it is believed that the retinal illumination decays exponentially (from white light stimuli), but the after-images caused by other colours may decay at other rates. The actual detection threshold is inversely proportional to flash duration.

5. The human eye can nevertheless distinguish between extremely short spaces between flashes (pulses of light). Experiments have shown that 4 millisec intervals can be distinguished from intervals as little as 0.28 millisec. Hence, in the context of UAP observations, pulsed (i.e. modulated) lights should be distinguishable by observers, even with very short durations - and should not get mis-reported as steady lights. This is

important, for example, in the context of lights which are 'chopped' by helicopter blades (~50Hz for a main rotor four-bladed Helo).

6. **Flash Duration Dependency** An important finding is that a given amount of light produces the same after-image (except for the first 15 sec), irrespective of whether it is delivered within 15.7 millisec or spread over 1.68 sec. This, is consistent with the hypothesis that the after-images of a brief stimulus from the 15th second until its disappearance at t=100 to 300 seconds later, depends upon photochemical effects. It does not depend upon adaptation or neural mechanisms in the retina or brain (as a result of the activity it is presumed the brain undertakes immediately after an eye stimulus).

7. It is probable, from the evidence available, that, after the first 15 seconds, neural effects contribute to the perception of the image seen. Up to five seconds after a stimulus (flash) it is nevertheless believed that neural as well as retinal (chemical) image perceptions are formed particularly if the event is from an unexpected source. At t=10 seconds the after-images are nearly alike (when using the alternatives used for experimentation). By 15 seconds they are seen as alike.

8. **Observer Variability** Observer contrast, for 50% probability of detection (against a plain background), is a function of object luminance, size of illuminated field, object size, edge sharpness, shape, time seen, position in field of view, colour, motion and experience. Detection thresholds are largely independent of shape up to an expected ratio of 7:1.

SUMMARY OF RESULTS

9. Based on the limited data available; to a first order level:

- After-images in the eye are based on the total amount of light available, independent of time.
- The persistence depends on the chemical consequences in the eye's receptors, not in (5-10 sec case) the adaptation of the image by the nerves/brain response.
- For very short flashes (e.g. less than 4 millisec) high intensities have more effect than lower intensity stimuli when viewed against either bright or dim backgrounds.
- Colours observed following a flash of a particular colour are dependent on the viewing background thereafter.

RELEVANCE TO UAP SIGHTINGS

10. A large number of UAP reports are of very intense lights of diverse colours, some of which are only reported as being of very short duration. Some of these could be the after-images of even briefer flashes. Longer duration reports apparently (see para. 6) of up to five minutes in duration, could be attributed to flash stimuli, followed by an after-image. It would appear that sightings are unlikely to be caused by after images for longer than five minutes. After 10-15 seconds the human involved will be interpretging and adapting what is seen well beyond what is actually registered chemically, due to the flash, within the retina.

11. There is, of course, the possibility of the after-image being 'replenished' by successive intense flashes. However, many flashes are separate (i.e. single) events, e.g. lighting, unexpected (i.e. non-continuous) electrical flash-over from (national grid) power lines or overhead train power lines.

12. It seems unlikely that, on the occasion of multiple witnesses of UAPs, that they will all receive the same phenomena (after-image); since apart from human observer variability in eyesight, it is unlikely that they would all receive the same stimulus at the same time unless they were located very close together.

[1] "Discrimination of After-Images" G.S. Brindley, J. Physiology 147 (1959).

[2] "Further Studies of the Positive Visual After-Image C.A. Padgham Opt. Acta Vol. 4 1959.

WORKING PAPER NO. 5

DETECTION OF UAPs BY RADAR

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DETECTION OF UAPs BY RADAR

S.26 1. [redacted] Conventional theory and radar system operation suggests that (given a radar sightline), the following conditions should occur for radar (UAP) detection to take place:

(a) The target must be radar-reflective. (See Appendix A5)

(b) A minimum detectable signal must return to the radar receiver to satisfy the radar receiver - S/N requirements (i.e. minimum detectable signal).

(c) The signal must be displayed (i.e. in a modern system which uses preset thresholds the display/processing threshold must be adequate for the target being inspected).

For a target track to be formed (a), (b) and (c) must be repeated at the radar's inspection (i.e. update) rate. In modern systems supposed 'spurious' random responses are likely to be rejected/filtered and unless they fulfil 'plot' requirements, will never be declared from successive plots into 'tracks'. Hence, they will not be seen as targets.

2. There is a significant absence of radar plots/tracks on UAPs. It should be borne in mind that, statistically, it is inconceivable that **all** UAPs in the UKADGE are reported by direct (human) sightings). In fact, there must be many more UAPs unreported which are within radar coverage but not within human sightlines (e.g. due to cloud cover, reduction of observers in sparsely populated parts of the UK etc.). Why, therefore, are not at least even a reasonable proportion of these reported by military or civil radars, either at sea, over land or by aircraft radars?

3. **Possible Explanations** A number of explanations are possible. The conditions at para 1 above are not being met for one or more reasons:

a. For some reason the radar reflectivities of these unidentified objects are extremely low.

b. Because they do not 'communicate' or appear where aircraft are expected, they are ignored by the operators (or the automatic processing systems) as spurious/short-lived observations.

c. Those seen are taken to be caused by flocks of birds.

d. When moving fast they exceed the upper Doppler/Velocity capability of the system. This may be, firstly, beyond the Doppler measurement capability of the particular type of radar [redacted] S.26

e. The target cannot be seen because there is no radar sightline (e.g. terrain screening/low altitude). This can only be the case on a limited number of occasions, subject to range.

f. [redacted] S.26

g. The object absorbs RF energy at least at the usual wavelengths in use and hence is not detected.

h. [redacted] S.26

i. The objects are above the upper radar coverage capability (~100,000ft).

4. [redacted]

S.26

RADAR REFLECTIONS FROM PLASMA

5. A plasma is an assembly of small particles of three kinds, +ve, -ve and neutral; moving at random and colliding with each other. In all except very high current discharges there are many more neutral particles than charged particles. Electrons oscillate about a mean position, with angular frequency $\omega_0 = 2\pi f_0$, where $\omega_0{}^2 = 4\pi N_e e^2 / m$. The oscillations are linear and stationary and do not progress as waves. A plasma will reflect radar energy at all microwave frequencies below the "plasma frequency". A critical-density surface can be formed according to the density relationship:

$$N_e = 1.2\,4 \times 10^{10} f_o{}^2\ (\mathrm{cm}^{-3})$$

f_o is in GHz. For example, a value of $\geq 1.2 \times 10^{12}$ cm^{-3} will reflect X(I) Band and all frequencies below. Using these relationships the direct RF to density expression can be derived:

$$f_0 = \sqrt{\frac{N_e.e^2}{\pi m}} \text{ or } f_0{}^2 = \frac{N_e.e^2}{\pi m} + \frac{c^2}{\lambda^2}$$

where m = mass 9.11×10^{-28}g.

e = electron charge 4.8×10^{10} e.s.u. (1.6×10^{-20} emu or 1.6×10^{-19} coulombs)

This can be rearranged such that:

$$f_0 = 8980\sqrt{N_e}\,H_z$$

6. A plasma thickness may vary, hence:

- The location of the critical density 'mirror' is not necessarily at the outer extremity of the plasma.

- Some absorption of the incident energy can occur in the lower density region which the energy encounters before it penetrates to the depth of the critically dense region. This depends on the ambient air pressure.

- Incident radar energy may arrive at the plasma at various angles (θ), hence:

$$N_e = 1.24 \times 10^{10} f_0{}^2 \cos\theta.\mathrm{cm}^{-3}$$

- The refractive index of a plasma is always less than 1, given by:

$$\mu = \sqrt{1 - \omega_p^2 / \omega^2}$$

where ω is the radian frequency of the EM wave and ω_ρ is the plasma frequency which is related to N_e by:

$$\omega_\rho = 5.64 \times 10 \sqrt[4]{N_e}$$

7. Thus radar energy entering a medium of lower refractive index is a similar situation to total internal reflection in optics.

8. Calculations show that to reflect 10 GHz microwaves a plasma should be at least 1-2 cm in thickness and less than -20dB through-transmission. It is possible for very high RF energies to be reflected (although the case here is much attenuated by the arrival of a radar pulse having suffered propagation attenuation $\alpha 1/R^2$ (which will be repeated on the reverse journey for a monostatic radar inspection).

9. [redacted]

5.26

10. It should also be noted that the greatest visual luminosity occurs when the frequency of the oscillation of ions and electrons is equal to the applied frequency:

$$4\pi_e^2 / m\omega_0^2 = 1$$

BALL LIGHTNING AS A RADAR REFLECTOR

11. As stated at Working Paper No. 2, ball and bead lightning (which do not always appear as spheres), may have diameters as small as a few cm and as large as 12-15 metres. For the ball lightning sphere to 'float', its gaseous density is known (1.29×10^{-3}gm cm^{-3}), but its plasma density is not known, unless this can be deduced via its colour/temperature characteristic.

12. **Radar Echoing Areas** The radar echoing area of ball lightning would be expected to be of the order calculated from its physical size. A transition between a strongly reflecting target and an almost completely absorbing target occurs. The possible RCS values for plasma spheres are different from that of metallic spheres (who's RCS is a function of sphere radius and radar wavelength), with the radar echoing area of plasma spheres dependent also on ionisation level. An 'overdense' plasma sphere (or other shape) may be treated as a perfect reflector. However other plasmas depend, for their RCS, upon interference effects between the backscattered wave and tightly bound surface waves. This gives the plasma the properties of a dielectric, even when it is overdense. For example, a collisionless homogeneous plasma sphere with low electron density may have a RCS value of -60dB, peaking between 1 to 8m^2 as the density increases, but falling to 1m^2 as the density increases yet further. These values are for D/E(L) Band assessments.

DUSTY PLASMAS AS RADAR REFLECTORS

13. It is argued that 'dust' particles, possibly of ice, form noctilucent clouds. (These are of the type, see Working Paper No. 13, which are sometimes reported as UAPs) A more recent understanding of dusty plasmas is at Working Paper No 19 ''Charged Dust Aerosols'). It can be postulated that the plasmas containing these particles comprises two ionic components (one single charged atomic or molecular ion and a positive, or negative, multiple charged dust particle). Due to the tendency of the plasma to charge neutrally, a kind of charged cloud forms

around each charged particle in such a way as to compensate its charge.

14. In a two-component plasma with equal electron and ion temperatures it can be shown that the charge of the dynamic cloud of a single charged ion is composed of 50% attracted electrons and 50% of repelled ions. The roles of electrons and ions is reversed for the case of a negative ion. Hence, the number of electrons in the neutralising cloud may be small or large, depending on the densities and temperatures of the plasma components. Under these conditions a (EM) wave illuminating the plasma will set in motion the electrons in the clouds and if the scale of the dynamic cloud (Debye length) is much smaller than the wavelength of the illuminating wave, either coherent or collective scattering (from the electron component of the cloud) will occur.

15. It is beyond the scope of this brief paper to pursue the detail of the scattering, other than to note that for radar-wave scattering to be enhanced there must be no interaction between the dust particles.

16. The intensity of the scattering, as a function of the incident radiation λ_o, equals $2\pi/k_o$, where k_o is the wave vector number. There are two regimes with little intensity for long wavelengths ($2k_o\lambda_D^2 \leq 1$) and a regime at shorter wavelengths ($2k_o\lambda_D^2 \geq 1$). The radar scattering is caused by fluctuations of electron density. The scattered power per unit volume of illuminated plasma within an interval of solid angle, within a frequency interval $d\omega$ and at wave vector k can be calculated from the Thomson electron cross section;

$$\sigma_T = r_e^2 = 7.95 \times 10^{-30} m^2;$$

where $r_e = 2.82 \times 10^{-15}$m is the classical electron radius, E_o is the incident (E field) amplitude and $\varphi(\Omega)$ is a polarisation factor defined as:

$$\varphi(\Omega) = \left| \frac{k_s(k_s E_o)}{k_s^2 E_o} \right|^2$$

For backscatter $\varphi(\Omega)$ equates to 1. The full derivation is at[1].

17. Anomalous radar scatter has been received at RFs of 50, 224 and 933MHz, using experimental radars. The plasma is not fully ionised.

18. Strong backscatter from this cause occurs principally at high latitudes, in the summer and at considerable altitude (~80km).

DETECTION BY UK BASED RADARS

19. Backscatter from 'dusty' plasma at an altitude of, say, 80km could theoretically be obtained at a slant range of ~190km from a radar with a maximum elevation angle of ~25°. Those radars with a height-finding capability would soon reject the returns because the range/angle/altitude combination would place the target at an impossible altitude for manned aircraft. [redacted] S.26

20. The detection of phenomena other than mesosphere plasmas is also considered at Volume 3 and is necessarily classified SECRET as it involves the current detection performance of military operational systems.

RADAR SIGHTING REPORTS

21. In an attempt to correlate simultaneous or sequential radar sightings with radar types, only limited UK information is available. In December 1989, 5 NATO radars, part of ACCS, were within coverage range of a UAP report. Three radars had detections but two did not. Unfortunately, the radars have since been replaced and records of their parameters,

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[1] LaHoz.C "Radar Scattering from Dusty Plasmas" Physica Scripta 45. Univ. Of Tromso, Norway 1991.

in use at the time, are no longer available. In the 1960s, Preston Air Traffic radar had unexplained detections and, over various years, the F-16 Air Interception radar has occasionally made UAP detections. More recently, RAF Neatishead, RAF Waddington Airfield Approach Radar and the CAA radar at Claxby, apparently had simultaneous detections. In all these cases the electron density of the target must have been high enough for the RF in use to produce reflections.

22. Clearly, UAP response to radar is variable, otherwise all the radars would see all the objects which entered their respective coverage zones all the time. The implication of this would seem to be that at least the surface offered to a radar wavefront by a UAP target is not a consistent solid object. This variability may be due to aspect or orientation, material composition or both. If UAPs are plasmas, their intensity would proabably be diminishing as their physical life decays.

23. In the absence of firm radar cross-correlation the number of occasions where velocity could be deduced from actual measurements (compared, for example with purely 'eyeball' estimates of speeds obtained from some members of the public) are few. On one event a triangular (visual) formation was tracked on radar with an acceleration from 100 to 980kts in two seconds and an altitude change from 7000 to 3000ft in 1 second. This, of course, is feasible if the entities are charged bodies which are moving under the forces of electromagnetic or electrostatic fields. The Hessdalen lights, in Norway, for example, were reportedly tracked at a velocity of ~8.5km.s^{-1}.