LETTERS TO THE EDITORS

SPACE SCIENCE

Interaction of West Ford Needles with the Earth's Magnetosphere and their Life-time

The life-time of the copper needles which were to be placed in orbit for the West Ford experiment is a matter of great concern. It is generally believed that the pressure of solar radiation (*not* drag) will bring the needles down in about seven years provided they are launched into a 'resonant' orbit (for example, a polar orbit at altitude 3,800 km.); for a good description of the resonance effect, see I. I. Shapiro and H. M. Jones[1]. These authors also show that if the semi-major axis of the orbit is changed by more than 150 km., the resonance would be destroyed and the life-time greatly increased.

My earlier article[2] discussed the problem of the drag of a charged body moving through a plasma and considered also just how a body acquires an electric charge in space. Although originally applied to micrometeors, this work can be carried over directly to the West Ford dipoles, which are copper needles of length 1·77 cm., diameter $2\cdot8 \times 10^{-3}$ cm., and mass 10^{-4} gm. I calculate a capacity C of $1\cdot5 \times 10^{-13}$ farad (my earlier article[2] adopts the wrong value of capacity, and, through force of circumstances, went to press before I could correct it; all further results there must be changed in proportion).

A more detailed examination of the charging effects for the particular conditions of the magnetosphere where the needles are put in orbit still leads to a potential of the needles close to the value adopted earlier. Its 'effective' value is $-3\cdot6$ V. Hence the nominal charge Z is $\sim 3 \times 10^6$ electrons.

A further detailed examination shows that within a small error it is permissible to replace the needle by a point charge when calculating its total interaction force with the magnetospheric plasma. Then with the use of the relations given earlier[2], the drag force acting on the needles turns out to be $F \sim 10^{-23} Z^2 n$ dyne, where n is the ion density $\sim 3 \times 10^3$ H^+ ions per cm.^{3} at the West Ford orbit. The resultant rate of decrease of the orbit radius is $\sim 3 \times 10^{-10} Z^2$ km. per annum. Hence the orbit shrinks at the rate of $dr/dt \sim 3 \times 10^3$ km. per annum.

The greatest uncertainty enters into the determination of the electric potential of the needle. I estimate it to be within $-7\cdot2$ to $-1\cdot8$ V., with a probability of more than 90 per cent. With these extreme limits the orbit would shrink at a rate as high as $1\cdot2 \times 10^4$ km. per annum (33 km. a day) or as low as 750 km. per annum.

It is clear, therefore, that not only will the drag spoil the resonance but also it will in all likelihood provide an upper limit for the life-time which amounts to a few months, possibly as much as three years.

However, one cannot entirely exclude the possibility that the root-mean-square potential is less than 0·25 V., leading to $dr/dt < 15$ km. per annum (in which case the radiation pressure resonance would be preserved and the life-time would be $\sim$ 7 years); or that the root-mean-square potential is about 0·36 V., leading to $dr/dt \gtrsim 30$ km. per annum, in which case the resonance would be destroyed and the life-time *increased* to nearly a century.

A detailed report has been prepared and will be published later.

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[1] Shapiro, I. I., and Jones, H. M., *Science*, **134**, 973 (1961).

[2] Singer, S. F., *Nature*, **192**, 303 (1961).

PHYSICS

Lattice-type Vibrations in Associated Liquids and the Origin of Anomalous Rayleigh Scattering

When a sample is irradiated with monochromatic light of frequency ν_0 and the scattered light at right angles to this incident beam examined by means of a spectroscope, a line spectrum is observed containing besides the Rayleigh component ν_0, the Raman lines $\nu_0 \pm \Delta E_i/h$, where ΔE_i are the energy differences between stationary states of the sample. Although an arc having a relatively isolated line is normally used as the source of monochromatic light, all arcs do give rise to some continuum and this also appears in the spectrum as Rayleigh scattering. This continuum can be reduced by a carefully designed arc (such as the Toronto type[1] mercury arc), while the Rayleigh scattering is minimized by preparation of the sample for investigation in an optically clean condition. However, even under such favourable conditions some continuous scattering does occur, but the fact that it appears to depend on the nature of the scattering medium, extending less than 100 cm.$^{-1}$ from the exciting line in the case of unassociated liquids[2-4] and their corresponding solids and many hundreds of cm.$^{-1}$ in the case of highly associated liquids[5] and solids, would suggest that it is not Rayleigh scattering as is often thought. Its origin is, therefore, of interest, and it is the purpose of the present communication to discuss the possible sources of these anomalous Rayleigh 'wings'.

Phonon scattering, giving rise to a Brillouin spectrum, can be quickly ruled out as the major cause of this broadening since the velocity of sound in liquids and solids is of the order of 10^5–10^6 cm.sec.$^{-1}$, corresponding to frequency shifts of only $\sim$ 1 cm.$^{-1}$ at 4,000 Å.

In unassociated liquids and their corresponding solids, rotation of the molecules should give rise to broad wings on either side of the exciting line, the broadness of these wings depending on the rotational constant and the temperature, and in general being less than 100 cm.$^{-1}$ for all but very light molecules. This is normally believed to be the predominant cause of the Rayleigh wings in these systems[3,4,6]. Although in associated liquids and solids rotation of molecules