of about 4×10^7 m (25,000 miles). This follows from the observed length of the streak and the known distance of the comet from the Earth at the time. It does not follow, of course, that there is a solid nucleus of this diameter since even sparse dust in sufficient depth can cause enough opacity.

(2) The opacity is caused by dust, not gas, and this dust has a low albedo, otherwise the comet would have been much brighter.

(3) If we assume as usual, that the particle size distribution obeys a power law $n(a) = ka^{-p}$ with $p = 3$ for small particles[1] and 4 for larger ones, and that the space density of particles varies inversely as the square of the distance from the centre of mass (or nucleus if there is a nucleus) as required by a simple continuity equation, then it is possible to calculate what we might call the 'opacity radius'—the distance from the centre of mass at which a light beam must pass in order to be attenuated by a factor 1/e. Alternatively if this radius is known then the mass enclosed within a sphere of this radius can be computed. A simple formula can be derived: $M = (2/3)a\rho D^2$, where D is the opacity radius, a is the upper limit of particle radius and ρ is the material density of the particles. Here we have apparently $D = 2 \times 10^7$ m and $a = 10^{-4}$ m (ref. 2) since the power law seems to break down for large particles; and if $\rho = 3$ then $M = 8 \times 10^{13}$ kg; $\rho = 8$ gives $M = 2 \times 10^{14}$ kg.

Fig. 1 Comet 1973f at 1945 on 1974 January 9. In white light, exposure 80 s at f/2 on Kodak Tri-X Pan film. The head had a magnitude of +3.5 at this time. The three bright stars at the top of the field are (from left to right): 46 Capricorni, ξ Aquarii, β Aquari.

These figures agree well with the estimates made by Whipple[3] for the total mass of a comet and suggest the possibility that the whole mass may be contained in the dust cloud. There would be ample surface area, 3×10^{15} m^2 if the particles are spherical, more if they are not, for the adsorption of gases and sufficient opacity to prevent them from volatilising too quickly.

We thank the Royal Society for financial support and Professor Francisco Sanchez Martinez of the University of La Laguna for the use of his facilities at the Observatorio del Teide at Izaña.

G. R. Hopkinson
Yvonne Elsworth
J. F. James

The University of Manchester,
Schuster Laboratory,
Manchester, UK

Received February 15, 1974.

1 Ingham, M. F., *Mon. Not. R. astr. Soc.*, **122**, 157 (1961).
2 Finson, M. L., and Probstein, R. F., *Astrophys. J.*, **154**, 327 (1968).
3 Whipple, F. L., in *The Moon, Meteorites and Comets*, (edit. by Middlehurst, B. M., and Kuiper, G. P), chapter 19 (Chicago University Press, 1963).

Atmosphere of Mercury

The recently released news concerning the possible atmosphere surrounding Mercury seems to have taken the astronomical community by surprise. It had generally been expected that because of the high temperatures (of the order of 450 K) existing there and also because of the low surface gravity, any atmosphere originally present, or any released from subsequent events on the surface would quickly evaporate since the random thermal speed of the atoms would be greater than the escape velocity. If V_E is the escape velocity from Mercury, ρ_A the density of its atmosphere and A the surface area, then a simple computation indicates[1,2] that the rate of mass loss from this atmosphere is

$$\frac{dM}{dt} = \frac{A\rho_A}{\sqrt{(\beta\pi)}}[1+\beta V_E^2]\exp(\beta V_E^2)$$

where $\beta = m/2kT$, k being Boltzmann's constant and m the atomic mass. All this ignores the solar wind which carries mass into the atmosphere. In reality the problem becomes a boundary layer problem in which the magnetic field of Mercury plays a part, but we can see simply that the main effect is to generate an atmosphere. If the wind has a density ρ_W and a velocity V_W, then it adds matter to Mercury at the rate

$$\frac{dM}{dt} = AV_W\rho_W$$

and the stead state situation is given when

$$V_W\rho_W = \frac{\rho_A}{\sqrt{(\pi\beta)}}[1+\beta V_E^2]\exp(-\beta V_E^2)$$

or

$$\frac{\rho_A}{\rho_W} = \left[\frac{\sqrt{(\pi\beta)}V_W\exp(\beta V_E^2)}{[1+\beta V_E^2]}\right]$$

Inserting the appropriate numerical values, $\beta \approx 10^{-11}$, $V_E^2 \approx 2\times10^{10}$, and $V_W \approx 10^8$ (all in c.g.s. units gives)

$$\frac{\rho_A}{\rho_W} = 600$$

There should therefore be a very tenuous atmosphere, basically composed of hydrogen being maintained in this way. Any helium and argon released by radioactivity would become trapped in this atmosphere and should be detected.

If the atmosphere is signficantly denser than given above, it implies that volcanic activity or some such gas generating process must be active now.

I. P. Williams

Applied Mathematics Department,
Queen Mary College,
Mile End Road, London E1, UK

Received April, 11 1974

1 Jeans, J., *Dynamical Theory of Gases* (Cambridge Univ. Press, 1921).
2 Williams, I. P., and Crampir, D. J., *Mon. Not. R. astr. Soc.*, **152**, 261 (1971).

Existence of two groups in thermoluminescence of meteorites

The thermoluminescence (TL) properties of meteorites[1-4] may be applicable to the determination of exposure age, terrestrial age, thermal gradients, radiation history and preatmospheric shape. In an attempt to apply TL to the determination of terrestrial age we have discovered that meteorites can be divided into two groups, the existence of which is relevant to several of the applications.

Our apparatus consists of a molybdenum strip heated electrically at $5 \pm 0.05°$ C s^{-1} by an electronic control unit. The light emitted by 10 mg of 50 μm sieved powder placed on a defined area of the strip is measured by a cooled and shielded 9635B EMI photomultiplier tube. The amplified signal is plotted automatically against temperature. The resulting 'glow curve' has two peaks, one at about 200° C (LT) and one at about 350° C (HT).