the average frequency of impacts was approximately equal to 7·5/sec, which corresponds to 90 impacts/1 m^2.

During partial shielding of pick-ups from the Earth at altitudes of 1300–1500 km and 500–600 km, averages of 40 and 38 impacts/sec/m^2 respectively were recorded.

The spread at altitudes of 1700–1880 km was 90 ± 34, at 1300–1500 km was 40 ± 18, and at 500–600 km was 38 ± 10.

Proceeding from the assumption that the impulse detectable by the pick-up during the impact of a particle is proportional to its energy, then the meteor particles recorded have energies of the order of 10^4 ergs.

The piezo-electric pick-ups for recording meteor particles are also mounted on the frame and head section of the rocket. Those mounted on rockets differ in design and sensitivity from those just described on the sputniks; the sensitivity of the rocket pick-ups was smaller.

During rocket ascents the impacts of meteor particles at altitudes from 150 to 300 km were reliably recorded. The frequency of impacts, on the average, was equal approximately to 2·8/sec when the sensitive surface of the pick-ups was 900 cm^2. Scaled to 1 m^2 area this corresponds to 31 impacts/sec.

7. DIRECT MEASUREMENTS OF METEORITIC DUST USING ROCKETS AND SATELLITES

MAURICE DUBIN

The space density and the mass distribution of meteoritic dust in the vicinity of the Earth may be directly measured using rocket and satellite vehicles. In comparison with optical and radio detection of meteors, rocket measurements are capable of detecting particles with diameters from 0·1 to 10 μ. This range of particle sizes has been observed from photometric measurements of zodiacal light, by ground collections of deep-sea sediments and of the magnetic component of dust settling on flat surfaces, and collections from high-altitude aircraft. Direct measurements from rocket-launched vehicles appear the most reliable for identifying and detecting the meteoritic dust component: since meteor observations are not sensitive enough to detect this component, ground collections suffer from contamination of the terrestrial component of dust and variations resulting from hyper-velocity interactions with the atmosphere, while zodiacal light measurements are capable of determining the gross aspects of the cosmic dust in the ecliptic subject to assumptions of light scattering from solid particles.

Direct measurements of meteoritic dust from rocket-launched vehicles are also subject to a number of difficulties. In general, the limited time a rocket vehicle remains in the high atmosphere, even in the case of satellite vehicles, warrants the detection of the smallest component of meteoritic dust. This component has the greatest number density in space and hence allows one to obtain most easily a statistically valid sample of the dust component within the limited time that the detector is exposed. The impact of a micrometeorite upon an exposed surface results in the formation of a crater, a light flash, the ablation of surface material, and shock vibrations in the material. All of these effects have been utilized in various methods of detection of micro-meteorites from rocket-launched vehicles. The main difficulties have been the hyper-velocity calibration to determine the absolute sensitivity of the detector, and the exposure of a sufficiently large surface long enough to obtain a good sampling free of contamination and interference.

A number of measurements of meteoritic dust have been made from rocket-launched vehicles using a hyper-sensitive accelerometer designed by Bohn. This method employs a piezo-electric crystal in contact with the surface of the rocket vehicle. This technique is effective for a wide range of sensitivities over a large exposed surface, yet is simple, compact, reliable, and permits telemetry of the detected impacts. The electrical pulse generated in the crystal is amplified and then coded for telemetering. The equipment, after being mounted in the rocket vehicle, is calibrated to determine the sensitivity, the effective area, and effect of electrical and vibrational interference.

The calibration of this detection method has been effectively carried out. Theoretically, the method is sensitive to the momentum of the impacting particles. The momentum sensitivity is determined by dropping micro-particles of known mass on the sensitive surface. Further calibrations have been performed using particle accelerators well into the hyper-velocity range of velocities by various researchers. This calibration indicates that the detection method may be used to detect impacts of meteoritic particles of masses greater than 10^{-11} g.

The first direct measurements of meteoritic dust were made by Bohn on V-2 rockets on 1949 December 8 and again on 1950 August 31. The next measurements were made by the author on an Aerobee rocket on 1955 September 14. A series of five Aerobee rockets were instrumented by Bohn, Alexander, and the author and launched on April 9, July 16, July 18, October 14, and October 16 during 1957. On 1958 January 31 this instrumentation was successfully flown in Explorer I, the first United States satellite.

The models of the Aerobee rockets used reached peak altitudes between 100 and 200 km, permitting an exposure time to meteoritic impacts of a little more than 200 sec above a base altitude of 60 km. The data from the successful rocket flights were generally consistent. For example, the last Aerobee flight, on 1957 October 16 at $22^{h}\,12^{m}$ M.S.T., reached an altitude of 113 km. There were sixty-six impacts on the skin over a period of 200 sec centered around peak altitude. The effective exposed area was $0{\cdot}5$ m^2, resulting in $0{\cdot}66$ impacts/m^2/sec; the sensitivity in momentum was 5×10^{-4} g cm/sec. A second detector on the same rocket with an exposed surface area of $4{\cdot}3\times10^{-2}$ m^2 recorded fifteen impacts in the same time interval. Since the sensitivity of this detector was 10^{-4} g cm/sec, the impact rate of this detector of $1{\cdot}7$ impacts/m^2/sec when adjusted to the sensitivity of the skin detector, using a number distribution of meteoritic particles given by Watson, becomes $0{\cdot}34$ impacts/m^2/sec. There is a general consistency, even though the exposed areas differ by more than a factor of ten. Assuming an impact velocity of 30 km/sec the daily accretion rate of meteoritic dust on the Earth based upon this rocket flight is from 40,000 to 80,000 tons for particles of visual magnitude $+10$ to $+30$.

The data sample from the satellite Alpha 1958 is large in comparison to the rocket flight data. Explorer I had an effective exposed area of $7{\cdot}25\times10^{-2}$ m^2 and a threshold sensitivity of $2{\cdot}5\times10^{-3}$ g cm/sec. The running total for the partial reduction of the data indicates that for the first ninety passes of reduced data, a total of 20,900 sec of telemetering data with an excellent signal-to-noise ratio was obtained. During that time forty-five particle impacts were recorded, giving an impact rate of $3{\cdot}0\times10^{-2}$ impacts/m^2/sec. For an impact velocity of 30 km/sec, this corresponds to impacts of particles of mass greater than 8×10^{-10} g. The corresponding daily accretion rate of meteoritic dust by the Earth during February 1958 becomes $1{\cdot}3\times10^{4}$ tons/day.

The utilization of rockets and satellites for the direct measurement of interplanetary material in the vicinity of the Earth is just beginning. Measurements of the mass distribution at fixed impact velocity have begun. The mass distribution, the spatial distribution of meteoritic dust in the Earth's orbit, and the dependence upon radial distance from the Earth have still to be measured. Sporadic conditions of clouds of particles, already detected from the satellite measurements, must be further investigated. The distribution of orbits and velocities of these particles in the vicinity of the Earth may also be directly determined. The composition and structure of these particles may be studied. This type of information may have great bearing in geo-astrophysics, the study of comets, asteroids, the solar system, the understanding in geophysics of the airglow, the gegenschein, zodiacal light, noctilucent clouds, sporadic E, the aurora, and the pattern of world-wide rainfall.

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