CHAPTER V

THE DIRECT EXPLORATION OF THE EXTRATERRESTRIAL WORLD

1. The Direct Exploration of the Moon

Table II (pp. 9–11) summarizes the major phases of the exploration of the moon: lunar impact (Luna 2), photographs of the invisible side (Luna, Lunar Orbiter, etc.), high resolution photographs (the Ranger series), close-up photographs of the surface itself (Zond 3), circumlunar orbits (Luna 10, Lunar Orbiter, etc.), attempts at analyzing the mechanical and chemical properties of the lunar soil (Surveyors), and most recently the manned landing on the moon (Apollo XI) with the return of samples of lunar material, as well as many other experiments. Obviously between the time this paragraph is written and the time it is read, other experiments will have been carried out, new data acquired, so that much of what is written below may be out-of-date.

What are the problems that have been solved by the success of these launches? Also, what are the problems that can be studied by future launches, or at least by the nearest ones to come?

We know that the moon is one of the largest satellites in the solar system. While it is no longer our only satellite (since there are so many artificial ones!) it is at least by far the biggest and most notable one. Nevertheless its mass is too small to have retained an atmosphere, if ever one existed. This conditions the appearance of the moon, traditionally considered to be a ‘dead’ body. Galileo discovered its relief; starting with his observations, a regular lunar cartography has developed, and continues to be elaborated (from earth observatories) to satisfy the rebirth of interest in lunar problems stimulated by progress in astronautics. The optimum resolving power (limited by the earth’s atmosphere and by the size of the instruments) used to be 1 or 2 km on the moon; smaller details were unobservable. By measurements of the radiation reflected by the moon (eclipses, infrared, radio region), the temperatures and the conductivity, as well as (by polarization) the microscopic structure of the surface, can be determined. Photometry of craters is involved in the detailed topographic study of the moon. Where astrometry and celestial mechanics are concerned, the moon, as the only natural earth satellite, is a body of considerable importance: the study of its distance and its orbit yields a determination of the sun-earth mass ratio; the dynamical theory of the motion of the moon involves the problem of perturbations by a third body (the sun); finally the theory of tides is closely related to the study of the moon’s orbit, and the precession of the equinoxes is also a result of the moon’s attraction on the earth.

The origin of the moon and its relief has always been a problem of interest to
theoreticians: Was the moon ejected by the earth? This hypothesis appears impossible according to the laws of mechanics. It seems more likely that the moon was formed by a cumulative process of agglomeration within the dust cloud surrounding the sun during its birth. Are the craters due to volcanic eruptions? Spectroscopic observations by Kozyrev have shown a weak but measurable emission in the Alphonsus crater, extending over wavelengths longwards of a sharp cut-off at 4740 Å (Figure 27). This emission is attributed to a band of the carbon molecule C$_2$. Several eruptions of this type have occurred in the Alphonsus crater, and this is a further argument in favor of

![Emission spectrum observed in the Alphonsus crater](image)

Fig. 27. Emission spectrum observed in the Alphonsus crater (according to the work of Kozyrev). Above: Kozyrev's observations; below: molecular band spectrum of carbon C$_2$. The rather good agreement of the emission peaks is notable.

the internal origin of these clouds of soot. Is this true volcanism? That is not certain: in fact the soot is not hot, and the analysis shows that it shines by fluorescence alone (and these measurements remain highly controversial!). Many astronomers argue strongly in favor of a 'meteoritic' origin; for the most part they refer to the evidence of laboratory experiments, in which one attempts to reproduce crater formation by the impact of various materials fired onto different targets... The results are always convincing, indeed too convincing, for in the present state of our knowledge, they show how much the problem remains unsolved. Moreover it can be shown that the relation between the depth and diameter of a crater (Figure 28) is the same for lunar craters as for bomb craters (objects falling to the ground) on earth. On the other hand, terrestrial meteorite craters do not obey this relation. Is this an argument against the meteoritic theory of lunar craters? Probably not, since over the course of time erosion has levelled and filled up the terrestrial formations, and this is probably not the case on the moon, where erosion is far slower (Figure 28). On the other side also,