

Orbiting the Sun

F. Whipple

December 23–25, 2015

Much has happened in planetary research in the last few decades, so why read an old book from 1980? Will not most of it be obsolete? Remarkably little I would say. In fact by 1980 the revolution had already taken place, and what has been added since then is just more facts of the same kind. When I first came across astronomy as a child in a small booklet¹ back in 1957, Sputnik had not yet occurred and would not do so until the coming fall². In the late 50's the Russians (who had the edge) and the Americans were still trying to hit the Moon with a rocket repeatedly missing. Space was very topical in those days. The Soviets were first with a crashing on the moon in 1959 I recall from memory, and even more spectacularly orbiting the Moon and sending back pictures of its far side, which hence were spotted with revolutionary names (winners take all). Still in the 60's all pictures of planetary discs and the Moon were taken by ground based telescopes. The first close ups of the Moon appeared in the mid 60's, and I recall how much they excited me. It was incredible to actually see a stone on the Moon's surface. At the time there were speculations that the surface of the Moon would consist of loose dust making any landing impossible. At the time the Russians also managed a soft landing on Venus, but that did not make the same impact on the public imagination. After that there was the Moon landing, which I watched in a student dormitory in Bucharest, and for a few years repeated visits to the Moon, but by 1972 funding ran dry, it was just too expensive and the element of specularity waned. Since then no human has left any indelible foot prints on the Moon. Instead there were interplanetary expeditions and fly-bys. This was low budget by NASA standards, but as Freeman Dyson has remarked, no other project sponsored by NASA has been as scientifically fruitful. In 1976 there was the Mariner searching for life on Mars (which highlighted the difficulty of what life should mean in a wider sense, not confined to the DNA based phenomenon which serves as a definition on Earth) and then the close encounter with the Jovian ambience, discovering new moons, unexpected rings and most intriguingly surface features on the Galilean Satellites. For someone who had only seen planets viewed from a far, those close-ups were truly fantastic and excellent PR for the NASA agency.

Whipples book is written at a time when the first fly-bys by Jupiter had taken place, when there were images of the cratered surface of Mercury along with the major Moons of Jupiter. Also when the Alvarez asteroid hypothesis for dinosaurian extinction was gaining wide scientific acceptance. Thus really very little that I know by hindsight is not shared by the author at the time. This has the advantage that he is not overwhelmed by an

¹ I think I still have the booklet, I read it over and over again, and learned the names of planets and their vital statistics by heart.

² It was part of the International Geophysical year (which actually lasted more than a year) of which I would learn retrospectively.

embarrassment of riches, although already at the time the astronomical community was overflowing with data and tens and thousands of journal pages devoted to recent studies. Thus one learns the basic, or rather those things which are perhaps not quite basic but good to know in order to appreciate further insights.

Whipple is known for his dirty snowball theory of comets (a theory later modified to icy dirt balls) but of comets there is no mention. The solar system and how it is held together by gravitational forces constitute the introduction, however, there is no technical discussion, no mathematical derivation. When I first read the book some thirty years ago³ and remember to my surprise that the Moon's orbit as seen in reference to the Sun is concave (as the author puts it) or more appropriately encloses a convex region. It was however easy to check, and an indication that the Moon is not as tightly tied to its mother planet as the inner moons of Jupiter. There is a chapter on the discoveries of Uranus and Neptune, the first being fortuitous, the latter the result of some daring calculations based on Newtonian mechanics and observed irregularities of the orbit of Uranus. Then there is a presentation of the major facets of the Earth and how its interior can be mapped through seismic waves and the composition of the atmosphere and the Van Allen belts. The Earth having a very strong magnetic field, due to its molten iron core and relatively fast rotation, means that it produces protective shields against aggressive radiation from the Sun. It is followed by the basic facts of the Moon in particular its influence on the Earth, synodic periods as opposed to sidereal, tidal forces (without getting in computational detail, which is necessary for a more thorough understanding) and eclipses. One is then treated to a thorough discussion of the features of the Moon, its dark 'seas', its cratering, rimmed walls, rifts and luminous ejecta. Its loopsidedness is noted, due to the modern technological ability to measure distances by laser or radar to unbelievable accuracy. One noteworthy feature seems to be the almost total absence of moonquakes. The precise heating up of the Moon's terrain is listed. It goes from -153° during midnight to 101° at noon, and during a lunar eclipse the temperature falls precipitously indicating that the surface layer is rather thin and a good insulator giving cause to speculations about its fine-grainedness. However, the actual temperature is not of that much a concern for astronauts as there is no thick atmosphere and no cause for boiling inside it, the space suits being sufficiently adequate for temperature regulation.

After the Moon there is a chapter on Pluto, Mercury and Venus, to many readers maybe a rather strange association. At the time not much could be said about Pluto, and its companion - Charon - still being debatable. But by 1980 one knew that Mercury does not have fixed rotation visavi the Sun, but its period of rotation is two thirds of its revolution of 88 days, i.e. of 59 days. This has some strange effects. For one there is a cycle of 176 days, after which the planet is back at its original position as well as its direction. A further complication is due to the elliptic orbit which makes the movement of the sun vary significantly. In particular the movement of the Sun may at times be retrograde, which when the Sun is close to the horizon has some strange consequences, such as a

³ I have during my life had many periods of accentuated astronomical interest, the first occurring in 1957, then in my mid-teens 65-66 when I even had a telescope a 60 mm refractor, then a brief period in the mid 80's to be followed by a more intense one in the late 90's in connection with a project by Ellegård. The book I must have bought in 85-86 during my sojourn at UCLA and no doubt read at the same time.

temporary night to follow sunrise, before the sun once again rises in earnest. An example of the rather esoteric but intriguing aspects the author likes to bring up. The chapter on Mars is instructed by the Viking expedition in the mid 70's and the wealth of close-ups of the cratered surface taken, with a detailed discussion of what it might mean, as well as with speculations as to possible water present. Furthermore due to the Voyages mission in 1979 there are also close up pictures of its turbulent surface and even more interestingly those of its major satellites. Furthermore it also made known the existence of faint rings. But not only Jupiter but even Saturn had been visited by the time the book was written, with a close up of the satellite Mimas with its giant impact crater. Information on the transsaturnian planets are of course sketchy in comparison, and at the time, the status of Pluto as a 9th planet was not threatened. Whipple, long-lived as many astronomers had been present when Tombaugh had discovered the planet.

The last sections concern speculations of how the solar system came into being, in particular if the Moon was once part of the Earth, as suggested by Darwin's son⁴ or formed in the vicinity of the Earth or whether it was a capture). The present ideas are a revival of Kants old 18th century nebular hypothesis mathematically elaborated on by Laplace, but there is the problem of explaining why most of the angular momentum belongs to the planets, with Jupiter taking the Lion's share, and the Sun having only a minute claim. In this respect comets and asteroids are expected to play key roles as fossils of the early phases estimated to having taken place some 4.5 billion years ago. Modern techniques of determining the precise compositions of different isotopes play a crucial role, as it does in modern geology.

December 26, 2015

⁴ according to the author, I always thought it was Darwin's grandfather who came up with the idea.

Orbit and Rotation. The Sun, and everything that orbits it, is located in the Milky Way galaxy. More specifically, our Sun is in a spiral arm called the Orion Spur that extends outward from the Sagittarius arm. From there, the Sun orbits the center of the Milky Way Galaxy, bringing the planets, asteroids, comets and other objects along with it. Our solar system is moving with an average velocity of 450,000 miles per hour (720,000 kilometers per hour). Earth orbits the Sun at an average distance of 149.60 million km (92.96 million mi), and one complete orbit takes 365.256 days (1 sidereal year), during which time Earth has traveled 940 million km (584 million mi). Ignoring the influence of other solar system bodies, Earth's orbit is an ellipse with the Earth-Sun barycenter as one focus and a current eccentricity of 0.0167; since this value is close to zero, the center of the orbit is close, relative to the size of the orbit, to the center of the Sun. The sun orbits around the galactic center of the Milky Way. The gravitational pull that keeps the sun in orbit is due to all the mass (stars, gas, dark matter) lying closer to the galactic center than our sun. The other answers could be misleading in this regard -- the gravitational contribution of the supermassive black hole, Sgr A*, at our galactic center is completely negligible.