THE MOONS OF JUPITER—MARIUS AND GALILEO

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Simon Marius

The moons of Jupiter were notable for the argument in favour of the Copernican hypothesis they supplied to Galileo; it is to this astronomer that their discovery is generally ascribed, but there are other claimants to this honour, notably Simon Marius, a pupil of Kepler. "According to Humboldt," writes J. Ellard Gore, "the four bright satellites of Jupiter were seen almost simultaneously and quite independently by Simon Marius at Ansbach on December 29th, 1609, and by Galileo at Padua on January 7th, 1610. The actual priority therefore seems to rest with Simon Marius, but the publication of the discovery was first made by Galileo in his Nuncius Siderius, 1610." As Grant in his "History of Physical Astronomy" calls Marius an "impudent pretender" it has seemed worth while to ascertain what were the actual facts of the case so far as they could be found out after this lapse of time and the enquiry has not been without interest.

Simon Marius was born in Bavaria in 1570; he studied astronomy under Tycho Brahe and Kepler, and in 1604 was appointed Court-Astronomer to the Margrave of Brandenburg-Ansbach. In 1609 he procured a telescope with which he began to study the heavens, and he records that early in the December of that year he observed Jupiter and saw that it was attended by some faint stars, some preceding, and others following the planet, which he thought were in the background of his field of view, and not connected with Jupiter. When, however, later in the month the planet retrograded and the faint stars still accompanied it, he gradually became convinced that they were moving round it just as—according to the Copernican view—the planets circled about the sun. He began regular observations on January 8th, 1610, of the three satellites his telescope revealed; a short time later he acquired two excellent "Belgic lenses," and with the superior instrument he now possessed he discovered a fourth moon on January 22nd, 1610.

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We are now in a position to see how the question of priority stands. Galileo made his first observation of Jupiter on January 7th, 1610, when he noticed three faint star-like objects in proximity to the planet; on the 10th he began to suspect that they might be moons attached to that body; on the following day he became assured that this was the case, and also detected a fourth satellite. He announced his discovery to the world in 1610 in his "Nuncius Siderius." The observations of Marius in December, 1609, and the early part of the following month had convinced him that Jupiter was attended by three satellites; on January 8th he began to take accurate measurements of their positions relative to the planet, and on January 22nd he saw the fourth moon for the first time. An account of his discovery first appeared in 1612 in a work edited by him, called "Frankischer Kalender oder Practica."

So far as priority depends on publication, there can be no doubt that Galileo's claim is secure, but the above recital of the facts of the case will make most readers feel that Grant had little justification for his abuse of Marius. What Galileo thought of the matter we do not know very definitely, but when, later on in the same year, 1610, he found that Venus showed phases similar to those of our moon, he immediately communicated the information to Kepler so that he might run no risk of losing the credit of this discovery.

We may add that later on Marius published a set of tables of the motions of the four moons, and in this he undoubtedly had priority; he also discovered that Mercury showed phases similar to those of our moon, and thereby added weight to the argument of Galileo in support of the Copernican hypothesis. He died at Ansbach in 1624. He did much useful pioneering work in astronomy, but his fame was entirely overshadowed by that of Galileo, and his name is now known only to those whose curiosity leads them into the by-paths of the subject.

The Satellites of Jupiter

Jupiter is accompanied in its orbit round the sun by a magnificent moon-system, of which there are no fewer than nine members. We have described how the telescope in the hands of Galileo and

Marius revealed four bright ones in 1610; it was not until 1892 that a fifth was discovered visually by Barnard; the remainder were detected photographically, the sixth and seventh by Perrine at the Lick Observatory in December, 1904, and January, 1905, respectively, the eighth by Melotte at the Greenwich Observatory in 1908, and the ninth by Nicholson in 1914. While the first seven discovered move round Jupiter in the same direction as that body rotates, the two last found, which are also the outermost ones, revolve about their primary in the retrograde direction.

The moons first discovered were called by Galileo the "Medicean stars" in honour of his patron, the Grand Duke of Tuscany; they are now known as I., II., III., and IV., the one nearest to the planet being styled I. These four would all be visible to the naked eye on a clear, dark night, if they were not so close to their primary; III., the largest and brightest, would be of the fifth magnitude, and therefore an easy object to see. Their times of revolution are $1\frac{3}{4}$ days, $3\frac{1}{2}$ days, 7 days, and 16 2-3 days respectively, and their distances from the planet range from 262,000 to 1,169,000 miles.

The diameters of the four are respectively 2460, 2000, 3540, and 3350 miles; it will help us to form some idea of the size of those bodies if we recall that the diameter of our companion is 2160 miles, while the diameters of the planets Mercury and Mars are 3030 and 4230 miles respectively. The largest of the Jovian moons, III., if placed beside Mercury or even Mars would exceed them in brightness and thus appear as a very respectable planet. From the markings shown under favourable conditions, it appears certain that the third satellite behaves like our moon and always keeps the same face towards its primary.

Polar Caps

White polar caps have been seen on the third and fourth moons by Professor Barnard and Mr. Douglass. The former says they are "exactly like those of Mars. Both caps of the fourth satellite have been clearly distinguished, that at the north being sometimes exceptionally large." Barnard and Douglas stand in the very front rank as observers, and, therefore, their testimony as to these caps may be accepted with confidence, though we may find it difficult to provide a satisfactory explanation, especially in the case of satellite IV.

These two moons are, as we have seen, of considerable size, much larger in fact than our companion, but their densities are low, that of III. being 2.2, and that of IV. 0.6; hence, while the mass of II. is about double that of our moon, that of IV. is only about three-quarters.

The existence of caps on a planet or satellite, which vary in size, and sometimes are entirely absent, shows that the body in question possesses an atmosphere surrounding a solid interior and that the gravitational forces at the surface of such interior are sufficiently powerful to prevent the escape of the atmosphere into space. We have good reason to believe that our moon has been unable to retain the atmosphere with which it was in all probability endowed when in a molten condition, and it is difficult to see how satellite III. can have escaped a similar fate. From the exceptionally low density of satellite IV. it seems reasonable to infer that it is almost entirely gaseous, in which case we are at a loss to understand how, even if it could maintain its coherence, it could show polar caps. We have here another of the many interesting problems presented by Jupiter, which will no doubt be solved in due time.

The Remaining Satellites

The moons with which we have dealt are almost of planetary dimensions; the others are all very small. No. 5, which is probably about 75 miles in diameter, lies between I. and Jupiter, and revolves about its primary in just less than twelve hours. Nos. 6 and 7 are about 100 and 40 miles in diameter, respectively, and perform their revolutions about Jupiter in 250 and 260 days, respectively. The remaining two move, as we have said, round their primary in the retrograde direction; they are extremely small and their detection on the photographic plate was no mean feat. Compared with the other moons, they lie at great distances from Jupiter and it has been suggested that while the other moons have been generated from their primary by some evolutionary process which we do not as yet fully understand, the two outermost ones are asteroids or minor planets, whose orbital movements have brought them into such positions relative to Jupiter that they have been captured by that body and so added to its normal family—an interesting theory to which we hope to recur on some future occasion.