

The discovery of the Great Red Spot of Jupiter

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The author criticises the prevailing opinion that the old 'Permanent Spot' of Jupiter was discovered by Robert Hooke in 1664. An analysis of the available sources reaffirms the primacy of J. D. Cassini's discovery of 1665, and strengthens the conviction of the identity between the spot of the seventeenth century and the present Great Red Spot.

Introduction

In the most recent papers on the subject^{1,2}, the discovery of Jupiter's Great Red Spot is plainly ascribed to Robert Hooke. He is supposed to have glimpsed the marking in 1664, one apparition before J. D. Cassini's observations. Later in this paper, we will discuss the identity of the marking observed in the seventeenth century with the present Great Red Spot: for the moment let us agree with B. M. Peek's opinion, "[it] seems highly probable [that] the identification is correct..."³.

The account by Hunt and Moore² leaves no doubt as to the validity of Hooke's observation; nevertheless, it has been distinctly controversial. As late as the 1950s G. Ruggieri^{4,5} agreed with Antoniadi's criticism⁶ of Denning⁷ with reference to the primacy of Hooke over Cassini. The contrast between the evidence produced by (for example) Hunt and Moore and the negative opinions expressed by such renowned authorities is so striking as to suggest that a deeper analysis is in order.

The opinions of successive Directors of the BAA Jupiter Section – among the main authorities on the matter – are favourable to Hooke. Phillips⁸ and Peek⁹ limit themselves to agreeing with Denning, while Fox – the present Director – is more prudent: "It is to these men, especially Hooke, [that there] must go the credit for the discovery of what has proved to be one of the most enigmatic markings ever seen."¹⁰ The references given by all these authors show that the question crystallised at the epoch of Denning and Antoniadi, and so it is necessary to go back to them in order to resolve the problem.

Denning's sources

Denning¹¹ quotes two extracts from Volume 1 (abridged) of the *Philosophical Transactions* of the Royal Society, pages 3 and 60. The first, which I quote completely, deals with Hooke's discovery; the second reports widely on Cassini's observations during the following years, on his determination of Jupiter's rotation period and on the visit that a delegation of the Académie Royale des Sciences paid to the Observatory of Paris in order to verify Cassini's predictions on the

transit at the Central Meridian of that enigmatic feature. (Incidentally, this visit was quite successful.)

Here follows the passage that Denning emphasises as a support to Hooke's primacy:

"The ingenious Dr. Hooke did some months since intimate to a friend of his that he had, with an excellent 12-feet telescope, observed, some days before he then spoke of it (viz., on 1664 May 9 O.S.), about nine o'clock at night, a spot in the largest of the three obscure belts of *Jupiter*; and that, observing it from time to time, he found that, within two hours after, the said spot had moved east to west about half the length of the diameter. It is situated in the northern part of the southern belt. Its diameter is one-tenth of *Jupiter*; its centre, when nearest, is distant from that of *Jupiter* about one-third of the semi-diameter of the planet."

It is interesting to note that this is essentially the same extract as is quoted by Hunt and Moore who, therefore, had Denning as their primary source. (This will be made clearer below).

From the references given, it is quite evident that Denning consulted the *Phil. Trans.* abridgement¹² published in 1809. A simple inspection of that volume, however, leaves the reader somewhat perplexed. On p. 3 we read:

"A Spot in one of the Belts of Jupiter. By Mr. Hook.
No 1, p.3.

"The ingenious Mr. Hook did, some months since, intimate to a friend of his, that he had, with an excellent twelve-foot telescope, observed, some days before he then spoke of it (viz. on the 9th of May 1664, about nine o'clock at night) a small spot in the largest of the three obscurer belts of Jupiter; and that, observing it from time to time, he found, that within two hours after, the said spot had moved from east to west, about half the length of the diameter of Jupiter."

On p. 60, under the heading "The Rotation of Jupiter on his Axis. By Mr. Hook and M. Cassini.", we have a shortened version of the foregoing passage followed ("according to Cassini") by the description of a theory about the double nature of Jovian markings – partly due to the satellites' shadows and partly dealing with the genuine surface features. With respect to the latter we read:

"Among these spots, there is none so observable as that situated in the northern part of the southern belt. Its diameter is $\frac{1}{10}$ of Jupiter's; its centre when nearest is distant from that of Jupiter about $\frac{1}{3}$ of the semidiameter of that planet."

A Spot in one of the Belts of Jupiter.

The Ingenious Mr. *Hooke*, did, some months since, intimate to a friend of his, that he had, with an excellent twelve foot Telescope, observed, some days before, he then spoke of it, (*videl.* on the ninth of *May*, 1664. about 9 of the Clock at night) a small Spot in the biggest of the 3 obscurer Belts of *Jupiter*, and that, observing it from time to time, he found, that within 2 hours after, the said Spot had moved from East to West, about half the length of the Diameter of *Jupiter*.

The Motion of the late Comet predicted.

Figure 1. Hooke's original announcement as it appeared in the first volume of the *Philosophical Transactions*. (Courtesy of the Royal Society Library.)

A comparison of these passages with Denning's extract is of the utmost interest. In the first sentence Denning made a number of transcription mistakes, among which the loss of the adjective "small" in reference to the "spot" is rather disquieting. But above all it appears clear that the second part of Denning's extract comes from the erroneous collation of different texts. It is difficult to ascertain how this could have happened. The abridgements of the *Phil. Trans.* were compiled mainly for the purpose of selecting and of making easier the retrieval of relevant scientific literature, with less care being devoted to historical precision. This is perhaps the clue to explaining Denning's mistake: from this perspective, it might have been due simply to an over-hasty reading.

In any case, it is clear that reference to the work of Denning is inadequate as evidence in relation to our problem.

Hooke's claim

It is therefore necessary to go back to the original sources which, as far as the *Phil. Trans.* are concerned, offer the following evidence (according to a note in Vol. VII, p. 4039, 1672):

- 1) Hooke's original announcement of 1664 (No.1, p.3.);
- 2) A reference to Hooke's observation about the possibility that Jupiter might rotate around its axis (No.4, p.75);
- 3) The clear attribution to Hooke of the first sight of the Permanent Spot, the study of which had proved determinant in establishing the rotation period of the planet (No.8, p.143);
- 4) A sharp defence of Hooke's primacy against the claims of Eustachio Divini, which was a sort of publicity for his telescope production (No.12, p.209);
- 5) An interesting report by Hooke of his observation of Jupiter on 1666 June 26, where no mention was made of the Permanent Spot (No.15, p.245);
- 6) A comprehensive report, by Cassini, about the reappearance of the Permanent Spot in 1672 (Vol.VII, p.4040, 1672).

This last report is the paper that is shortened in the 1809 abridgement. As far as the relevant part is concerned, it reads as follows:

"Among these Spots of the second sort there is none so sensible, as one that is scituate between the two Belts, which in the disque of *Jupiter* are ordinarily seen extended

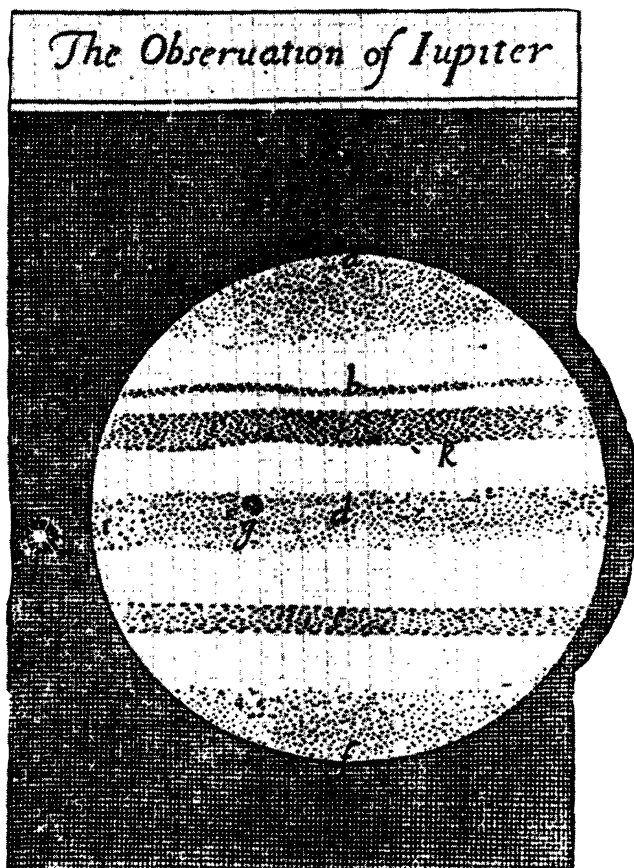


Figure 2. Jupiter as seen by Hooke on 1666 June 26. North at top. Note the large amount of detail, including the shadow of a satellite (g). Hooke used a 60-foot (18m) telescope with a magnification of about 180 \times . (From L. Rudaux, *Sur les autres mondes*, Paris, 1937.)

from east to west; the largest of which is between the Center and the Northern limb, and the narrowest is beyond the Center toward the Southern limb. This Spot is alwaies adhering to the *Southern Belt*; its diameter is about the tenth part of that of *Jupiter*; and at the time that its center is nearest to that of *Jupiter*, it is distant from it about the third part of the semi-diameter of that Planet."

The analysis of these texts displays two essential elements: the first is that Hooke's claim was supported only by the 1664 announcement; the second deals with the fact that his primacy was fully recognised by the Royal Society.

As far as the first point is concerned, a careful analysis of the original text, which is reproduced in Figure 1, leads one to agree substantially with Antoniadis's criticism. There is, in fact, no definite evidence to identify Hooke's spot with the Permanent Spot of the following years; rather, there are indications of the opposite.

The placing of the "small spot" in the "biggest of the 3 obscurer belts" suggests rather a marking embedded in what we now call the North Equatorial Belt, which is usually the most prominent feature of the planet. On 1666 June 26 (see Figure 2) Hooke himself described the NEB as the "great black belt" and the "bigger

belt", without mentioning any change with respect to his previous sightings of the planet. If the main belt in 1664 had been the South Equatorial Belt – an infrequent but yet possible appearance – then the placing would have been more correct (although not exact). But, in that case, it seems unlikely that the instrumental devices available at the time would have produced an impressive sighting of the Spot. It was not by mere chance that when Cassini detected the Spot, just one year later, it was standing out in the bright South Tropical Zone. It is also worthwhile noting that Cassini himself lost sight of the Spot over many apparitions between 1665 and 1694, presumably because of more complex scenes on the planet which his telescopes were unable to resolve.

To sum up, Hooke's description does not fit the appearance of the Red Spot as well as it does, for instance, the transit of a satellite shadow, or even that of Callisto itself which often shows a remarkably spotty image. At that time the transit of a shadow was, moreover, quite a noticeable event, and a report of a shadow transit was fully appreciated as a scientific contribution.

As far as the second point (the full support given by the Royal Society to Hooke's primacy) is concerned, while it is not negligible, it cannot by itself bear the full weight of proof. A sort of 'scientific nationalism' may well have played a part, as well as the preeminent standing that Hooke had already acquired inside the Royal Society. Hooke's difficult character – he was indeed a man of great scientific value but litigious too and "extremely jealous of his reputation as an original discoverer"¹³ – may also have led his colleagues to consent to the claim on trust.

Cassini's observations

As far as Cassini is concerned, it is beyond doubt that he repeatedly observed a spot quite like our modern Red Spot. It seems likely that his first observations were made at Città della Pieve, between the summer and the autumn of 1665; a full report was published the same year in the form of letters directed to the Abbot Falconieri¹⁴.

Cassini's interest in the spot concerned its use in determining the planet's rotation period, which at the time was unproven. His discoveries were the result of a careful working programme, which he described in the above-mentioned letters.

First he took care to single out – by means of computing – which spots were caused by the transit of a satellite or a satellite's shadow on the planet's disc. Secondly, Cassini demonstrated that the remaining observable spots had to be located on the true surface of the planet. Among these latter, he finally recognised a spot that was exceptionally conspicuous and permanent, and proved ideal for determining a highly reliable rotation period.

"To that first light of distinction then followed the other of detecting among the number of the other spots a permanent one which was often seen to return in the same place with the same size and shape. It is the same spot that Yr.Ecc. too was able to see just touching the real northern edge of that belt of Jupiter which, among the three obscurer ones, lies more southerly. That one, which among the spots hitherto observed is the greatest, the most conspicuous and the most permanent... appeared to be different in colour, not so dark and black [as the shadows], but quite like that of the obscure belts... different in figure as being, when nearer to the centre, larger in accordance with the line of the belt which it grazes, or narrower when nearer to the circumference."¹⁵

With these words Cassini described for the first time Jupiter's Great Red Spot.

On the basis of his own observations, which amounted to no less than thirteen between August 19 and October 30, Cassini compiled a *Table* of the transits of the Spot¹⁶, from which he derived a rotation period of 9h 56m. His results were confirmed, on more than one occasion, by two groups of observers in Rome. The groups were headed by the well-known telescope makers and observers Campani and Divini, and Cassini had frequent contacts with them around that period. The fit between the computed and observed times of transit was excellent, and the *Table* confirmed that a previous observation made on July 9 by the Divini's group – when a spot ('semiumbram') was seen to accompany the transit of the shadow of the third satellite – was also of the Permanent Spot (see Figure 3).

Here we find a trace of Divini's claim, and it can be readily agreed that the first reliable recorded observation was made by means of Divini's telescope. However, this is quite a different matter from that of the discovery itself. The discovery must include the main distinctive feature of the Spot – its permanence. This fundamental attribute was realised, and above all established, by J. D. Cassini.

Of all the spot's distinctive features, Cassini missed only its red colour, but it is out of the question that he would have been able to distinguish it because of the low light-grasp of telescopes of that time.

The many observations that Cassini made in Paris from 1672 to 1694 – he had been appointed Director of the newly-built Royal Observatory – do not add anything of importance on the subject.

The Permanent Spot and the Great Red Spot

As already mentioned, the identity of the old Permanent Spot with the modern Red Spot is rather uncertain. Although I have no further evidence – beyond those discussed by Denning and Antoniadi – a few considerations may be worthwhile.

The facts are as follows. Cassini and his successors observed the Permanent Spot until 1713. During that period many interruptions occurred in the records,

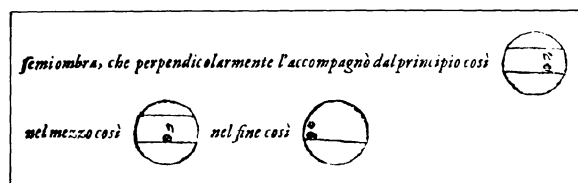


Figure 3. The observation of Jupiter made in Rome on 1665 July 9 by Divini, Fabri, Gottigniez, Serra *et al.* South at top. This is the first recorded observation of the Red Spot, which was seen to accompany the shadow of satellite III (at the bottom). The sketches, taken from a letter of Serra to Cassini, were printed by the latter in his *Dissertationes Astronomicae Apologeticae*. (Courtesy of the Library of the Paris Observatory.)

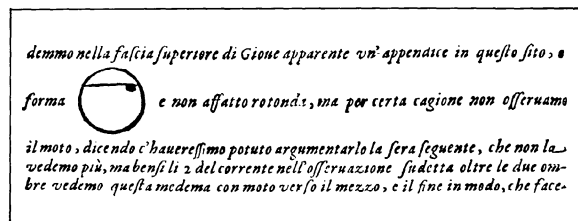


Figure 4. The well-known observation of the Spot made by Cassini on 1665 August 31. (Courtesy of the Library of the Paris Observatory.)

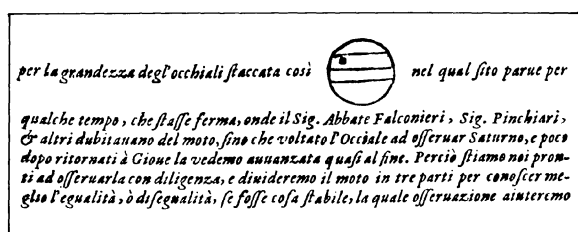


Figure 5. Another impressive sketch of the Red Spot observed by Serra, Falconieri, Pinchieri *et al.* in Rome on 1665 September 13. The telescope, by Campani, had a focal length of about 15m. From the same source as Figure 3. (Courtesy of the Library of the Paris Observatory.)

interruptions which we can almost certainly ascribe to the lack of instrumental power. This limitation was the more severe because astronomers had not recognised the association between the Spot and its Hollow – a decisive aid to locating the Spot when it is a difficult object. Completely forgotten for many years, the Spot found its way again into astronomical chronicles in 1878 when an American astronomer – C. W. Pritchett – thought that he had discovered it. The astonishing appearance demonstrated by the Red Spot in those years, already marked by a growing interest in planetary observations, awoke the attention of many astronomers. Thanks to the work of such authors as S. Williams and Denning, they were soon able to go back to 1831 when a drawing by S. Schwabe shows the unmistakable figure of the Hollow. Since 1878 the Red Spot has been watched regularly, right up to the present day.

During the long period from 1713 to 1831 there is unfortunately only the trace of some uncertain observations which Schroeter¹⁷ made in about 1790. It would be of the utmost value to find new observations for that period, since its lifetime and motions are of paramount importance in testing any theory on the nature of the Spot.

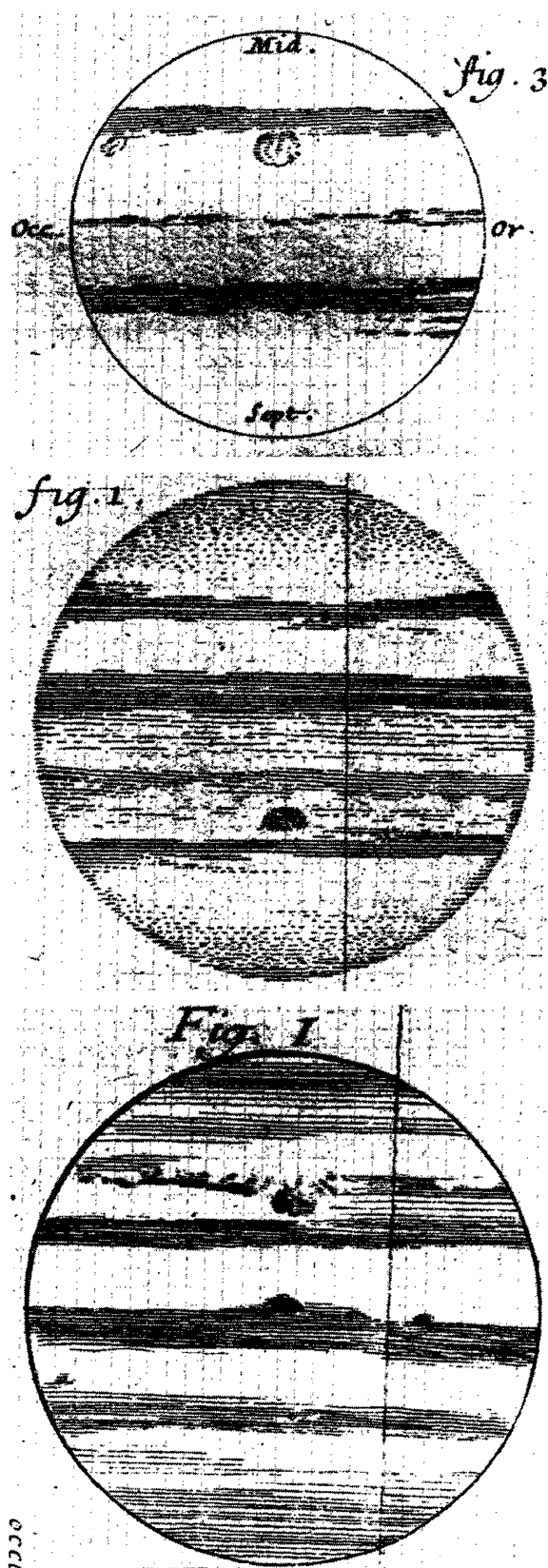


Figure 6. Three beautiful prints of the Red Spot by Cassini: (a) 1672 January 19, south at top; (b) 1677 July 8, north at top; (c) 1691 January, south at top. From the *Memoires de l'Académie Royale des Sciences de Paris*, t.10. (Courtesy of the Library of the Istituto Salvemini of Florence.)

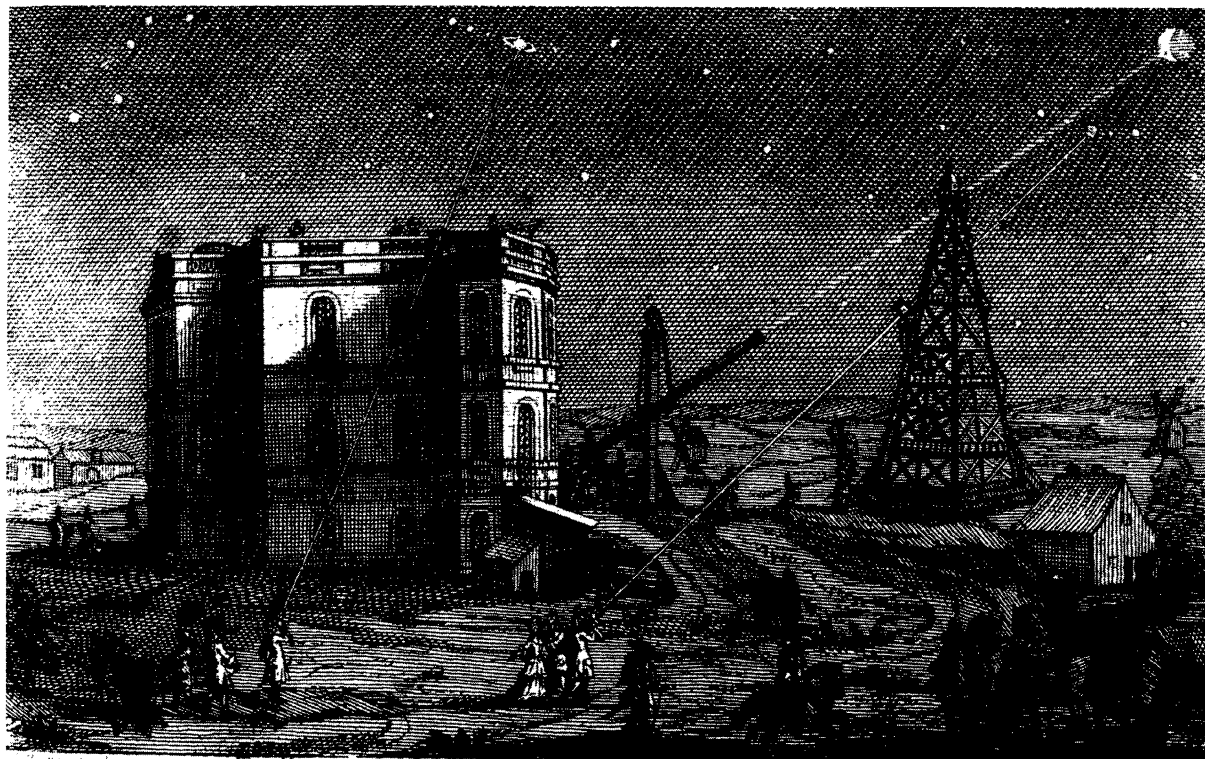


Figure 7. The Paris Observatory in the early eighteenth century: a Lunar and Planetary Laboratory *ante litteram*. From J. Cassini, *Tables astronomiques du Soleil...*, Paris, 1740. (Courtesy of the National Central Library of Florence.)

With the limited evidence at their disposal, Antoniadi and Ruggieri did not hesitate to maintain the identity of the two objects. More cautiously, Denning and the Directors of the BAA Jupiter Section limited themselves to giving credit to such a thesis, even if only implicitly on some occasions. Caution is justified partly by the lack of observations for more than one hundred years. This does not exclude, of course, the possibility that a more or less detectable Spot might have been present. It is not difficult to ascribe to instrumental reasons the general neglect of planetary observations which characterised the eighteenth century. It was only in the second half of the nineteenth century that, thanks to the improved achromatic object glass, such studies recovered strength, and there was a new ardour that led to the well known renaissance in planetary observation at the end of the last century.

In any case, one conclusion is quite clear: even if the identity of the old Permanent Spot with the modern Red Spot is still in doubt, there can be no dispute over the identical nature of the phenomenon, and the discovery must be attributed to J. D. Cassini.

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