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Friendly Stilbon, fraudful Hermes. Schiaparelli and the rotation of Mercury

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Abstract: Starting in 1881, Giovanni Virginio Schiaparelli dedicated himself to observing the planet Mercury. Contradicting the results of previous astronomers, who had assigned Mercury a rotation period similar to that of Earth, Schiaparelli concluded that the planet's rotation period coincided with the period of its revolution around the Sun; in other words, Schiaparelli became convinced that the planet Mercury was in synchronous rotation, as the Moon is concerning the Earth. Today, we know this conclusion is incorrect, but Schiaparelli's error persisted for decades, being definitively disproved only in the mid-20th century thanks to new observational techniques. In this contribution, we will consider the explanations offered by scholarly literature regarding what might have misled Schiaparelli. While some authors emphasise the difficulties inherent in the observation itself, others stress different extrinsic factors (for example, Schiaparelli entertained the idea that Mercury could have an atmosphere and perhaps even living beings dwelling on its surface). Furthermore, an attempt will be made to compare the drawings from Schiaparelli's diaries, preserved in the Historical Archives of the Brera Astronomical Observatory, with the maps obtained in recent years by the Messenger probe.

Keywords: Mercury, Schiaparelli, History of Astronomy

1. Introduction

> What the length of [Mercury's] Days are... is not yet discover'd, because we have not yet bin able to observe... what time he spends in his diurnal Revolution upon himself.
>
> Ch. Huygens, *Cosmotheoros*, 1698

In every contemporary astronomy textbook or fact sheet about the planets of the Solar System, one may read that the rotation period of Mercury is equal to 58.65 terrestrial days. Rather uniquely in the Solar System, this value is a relatively recent discovery; while already in the 17th century, Cassini was able to calculate with a good degree of accuracy the rotation periods of Jupiter and Mars, Mercury's rotation proved to be a much more difficult challenge. It was only in the mid-1960s that the currently agreed-upon value was reached, and notably, it was not due to optical astronomy, but to the efforts of radio astronomers and astrophysicists working with the data gathered by the Arecibo radio telescope in Puerto Rico (Pettengill & Dyce, 1965; Colombo, 1965).

An early attempt dates back to the year 1800, when J. H. Schröter's observations of features on the surface of the planet led him to deduce a rotation period of approximately 24 hours; this figure became widely accepted by the astronomical community (Sheehan & Baum, 1995; Prockter & Bedini, 2010). Schröter's observations and calculations were further developed by F. W. Bessel in 1813, and this figure became widely accepted for most of the 19th century (Colombo, & Shapiro 1966). It was only in the

1880s that another astronomer, G. V. Schiaparelli, felt confident enough in the technical evolution of telescopes to attempt another measurement.

2. Schiaparelli's observations

Schiaparelli himself, who at the time was in his fifties and director of the Brera astronomical observatory in Milan, nicely summarizes the difficulties faced by anyone attempting to observe Mercury:

> Indeed, a telescopic examination of this planet is extremely difficult. Describing a very narrow orbit around the Sun, Mercury never appears in the sky at much distance from the great light and is therefore impossible to see in the full darkness of the night, at least near our latitudes. Observations carried out during twilight are likewise, with rare exceptions, destined to failure; [the planet is so low on the horizon that it has] that uncertain and blazing appearance, which to the naked eye is perceived as a strong scintillation; for this reason, the ancients already called it *Stilbon*, or the scintillating one. (Schiaparelli, 1889a, p. 284; English translation by the authors)

The solution adopted by Schiaparelli was simple: the planet was to be observed during the day. Starting in 1881, Schiaparelli's observations immediately led him to the conclusion that Schröter's and Bessel's conclusion of a 24-hour period was erroneous; the planet had the same appearance when observed at different times of the same day. Soon, Schiaparelli concluded that Mercury's rotation period was approximately 88 days, i.e. equal to its revolution period around the Sun; in other words, according to Schiaparelli, Mercury was in synchronous rotation concerning the Sun. While Schiaparelli waited until 1889 to publish his conclusions, he had already anticipated his ideas in a letter to his Belgian colleague François Joseph Terby dated 20 October 1882. Despite having started observing Mercury in the previous year, Schiaparelli had already come to the conclusion that the planet was tidally locked to the Sun and communicated this idea to Terby in the traditional manner European astronomers announced their discoveries: with a Latin poem.

> Je crois que mes recherches sur ☿ sont assez avancées pour Vous donner une première idées du résultat. Si je devais mourir avant de publier moi même, je Vous prierai de le faire, afin que ce résultat ne soit pas perdu pour la science. Les voici, couché en mauvais vers latins, suivant l'usage de nos pères:
>
> Cynthiae ad exemplum versus Cyllenius axe
> Aeternam noctem sustinet, atque diem:
> Altera perpetuo facies comburitur aestu
> Abdita pars tenebris altera Sole caret.
> Non tibi Tabropane amplius admiretur adusta,
> Urget quam Titan ignipotens radiis,
> Nec tibi Rhiphaei constricti frigore montes,
> Nec Thyle arctoi obrute nocte poli.
> Magnis Luna quidem vicibus torretur et alget,
> Nam quos tu menses, nuncupat illa dies:
> Sidus et infelix, quod primo volvitur orbe,
> Majori flamma stringitur atque gelu.[1]
>
> En voilà assez faire fuir les neuf Muses, y compris notre docte Uranie. Cura ut valeas. (Schiaparelli, 1963, p. 104)

Schiaparelli's intentions were further recorded in an 1883 letter to the British astronomer William Frederick Denning: "I have been able to see its spots many times, but not always with the necessary distinctness... for a rigorous investigation... I believe that by instrumental means, such as our 8½-inch refractor at Milan gives, it is possible to prove the rotation-period of Mercury" (Denning, 1891, pp.

[1] An English translation of Schiaparelli's poem is provided in the Appendix.

141-142). In the subsequent years, Schiaparelli tenaciously kept at it, carrying out more observations of Mercury and dutifully recording them in his notebooks, accompanying them with numerous drawings of the planet's surface as it appeared when seen through his telescope - first an 8½-inch Merz refractor, and later (after 1886) the large 49 Merz-Repsold refractor, which had been installed following a large investment by the Italian royal government, in its bid to turn Brera into an observatory of global prestige after the recent unification of Italy.

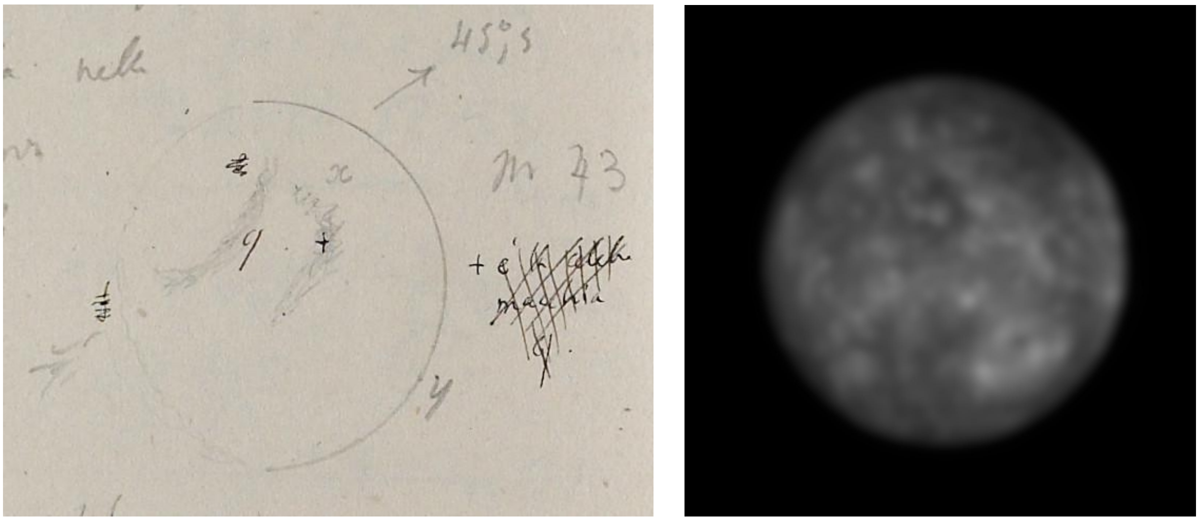
Schiaparelli's results and methodology were published in a paper in *Astronomische Nachrichten* in 1889. The method adopted by the astronomer was in essence analogous to the one adopted by his predecessors in determining the rotation period of planets: the identification of visible features on the surface, the locations of which could be used to calculate the speed at which the surface was moving, as anticipated in his aforementioned letter to Denning. Schiaparelli identified several "macchie" on the surface, and one (christened *q*) specifically caught his attention, as he believed he could always clearly identify it (unlike the other spots, which always remained much more confused and uncertain) (Schiaparelli, 1889b).

Schiaparelli was a skilled planetary observer, working with state-of-the-art telescopes; moreover, his 88-day result was widely accepted by the astronomical community for the entire first half of the 20th century. Eugène Michel Antoniadi went so far as to call Schiaparelli's conclusions about the rotation period of Mercury "la plus belle découverte télescopique du grand astronome italien" (Antoniadi, 1934, p. 23). Therefore, it is no wonder that subsequent authors occasionally wondered how exactly Schiaparelli concluded what we now know to be erroneous and why it took so long for the astronomical community to arrive at new results. Regarding the first question, Crowe (1986) suggests that Schiaparelli may have been influenced by the idea that a Mercury in synchronous rotation could be compatible with it being inhabited by living beings. Indeed, Schiaparelli announced his discovery at a public conference held by the Accademia dei Lincei, with King Umberto I and the queen consort, Margherita, in attendance; in this conference, Schiaparelli described the possibility that Mercury could possess an atmosphere and "something analogous to our seas" (Schiaparelli, 1889a, pp. 287-289). The atmospheric circulation in the form of strong winds, Schiaparelli hypothesised, might lead to the planet's temperature being more or less balanced between the diurnal half of the planet's surface and the nocturnal half. Defrancesco (1988) convincingly argues that Crowe's interpretation places too much emphasis on the issue of life on Mercury, and instead observes that Schiaparelli may have been influenced by recent developments in the theory of gravitation and of tidal forces; in other words, it is very plausible that Schiaparelli saw a direct analogy between the behaviour of Mercury regarding the Sun and the behaviour of the Moon in regarding the Earth (or in fact, any large natural satellite in regards to its planet). Adding to this discussion, a paper by Sheehan, Boudreau and Manara (2011) compares Schiaparelli's observations to contemporary images taken by CCD cameras; the authors emphasise that Mercury's surface presents numerous features that are very difficult to distinguish from each other by optical observation, being therefore comparable to a sort of "optical illusion" in which the brain is tricked into seeing spurious patterns and identifications.

Further developing this idea, the present contribution is an attempt to evaluate Schiaparelli's observations with the aid of digitally generated images of Mercury's surface.

3. Comparison with present-day observations

The task undertaken by Schiaparelli of identifying reliable reference points on the surface of Mercury to measure its rotation period is particularly difficult, not only for the reasons explained by Schiaparelli himself (1889a, pp. 283-284) but also because, as we know today, the surface of the planet is lacking any large, distinctive feature (as, for instance, the maria of the Moon) but is covered with several impact craters surrounded by complex ray structures which can be easily mistaken for one another. To assess these difficulties, we have tried to compare Schiaparelli's drawings with images taken with present-day methods, specifically with the maps obtained by the Nasa Messenger space probe, which provide a global coverage of the surface of Mercury. Among the different available renderings of Messenger's data, we have chosen the monochrome morphology mosaic (John Hopkins..., 2016) as the one providing images more directly comparable with Schiaparelli's drawings, although the correspondence cannot be exact, given the differences between the instruments used and the point of view of the observer.



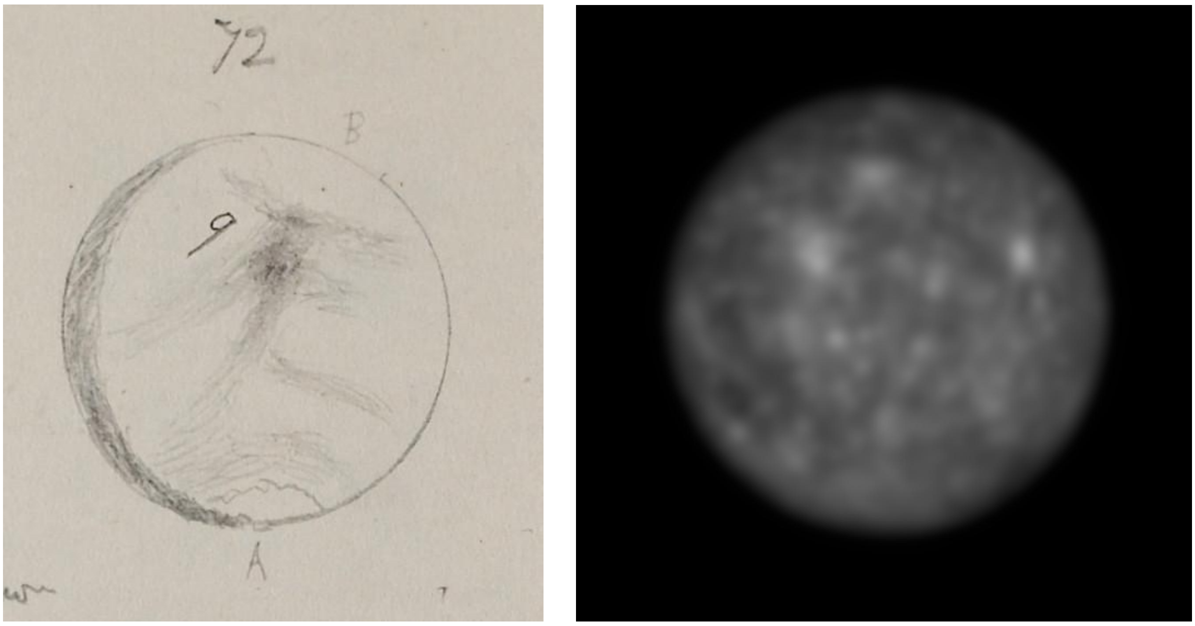
(a) **(b)**

Fig. 1: (a) Comparison between Schiaparelli's drawing of his observation of Mercury on 27.9 April 1882 (Schiaparelli, 1882). (b) The corresponding image obtained from Messenger's map.

In order to produce the comparison images, we have computed the geometrical parameters describing the relative positions of the Sun, Earth and Mercury and the rotational phase of Mercury, and in particular, the observer's sub-point (namely the apparent planetodetic longitude and latitude of the centre of the disc of the planet as seen by the observer) at the time of each observation, using NASA JPL's Horizons online ephemeris service (ssd.jpl.nasa.gov); then we have used these data to transform Messenger's map from its original equirectangular projection to an orthographic projection centred around the observer's sub-point, which mimics the appearance of the planet from the point of view of an observer on Earth, also taking into account the position of the Sun to darken the shadowed areas of the surface. These maps were subsequently blurred using an image manipulation program applying a Gaussian filter, to downgrade the resolution to a level more easily comparable to that of Schiaparelli's drawings; by trial and error the most suitable value for the radius of the filter was selected at 1/60 of the apparent diameter of the planet; then the contrast of the image was slightly enhanced to compensate for the decrease in contrast produced by filtering.

An initial interesting fact comes from the inspection of the orientation parameters themselves. In his paper published in *Astronomische Nachrichten* (1889b, p. 243) Schiaparelli attaches great relevance to the observation of a great system of spots (labeled *w*, *a, b, k, i* in Fig. 4), approximately in the same apparent position, during six eastern elongations in the period 1882-83.

Of course, these observations strongly support Schiaparelli's conclusion that the planet is corotating because, in such a case during homologous (western or eastern) elongations, the same region of its surface would point toward the Earth, except for small fluctuations caused by libration in longitude. However, suppose we compute (with JPL's ephemerides) the longitude of the observer's subpoint during



(a) **(b)**

Fig. 2: (a) Comparison between Schiaparelli's drawing of his observation of Mercury on 11.8 August 1882 (Schiaparelli, 1882). (b) The corresponding image obtained from Messenger's map.

Period	**Observer's sub point longitude (deg)**
February 4-10, 1882	73-104
May 24-31, 1882	271-305
September 19-30, 1882	159 -214
May 3-11, 1883	247-284
September 4-8, 1883	161-181
December 20, 1883	4

Tab. 1: Computed values of observer's sub point longitude during six eastern elongations observed by Schiaparelli (1889b, p. 243)

those periods (Tab. 1), we see that in reality, he was observing very different regions (in some instances, opposite faces) of the planet. This fact is confirmed by comparing Schiaparelli's drawings and the corresponding images obtained from Messenger's map. As an example, we include here the images related to two of the observations listed in the table published in the AN paper (Schiaparelli, 1889b, p. 246): observation no. 8 of April 27.9, 1882 (Fig. 1) and no. 16 of August 11.8, 1882 (Fig. 2); in Fig. 3 we position them on Messenger's global map of the surface of the planet; it is clear that the same label *q* has been assigned to two different (and quite far apart) features of the surface of the planet.

4. Conclusions

Schiaparelli, in his attempt to measure the rotation period of Mercury, embarked on a very difficult task at the very edge of what was possible for the observational instruments of his time, both because of the planet's tiny size and his perpetual closeness to the Sun. Working systemically, observing Mercury not only during dawn or dusk but also in the diurnal light, he managed to identify some discernible spots on the surface, thereby proving that the rotation period was not equal to approximately 24 hours (as was believed until that point) but instead much longer. However, when he tried to measure the period

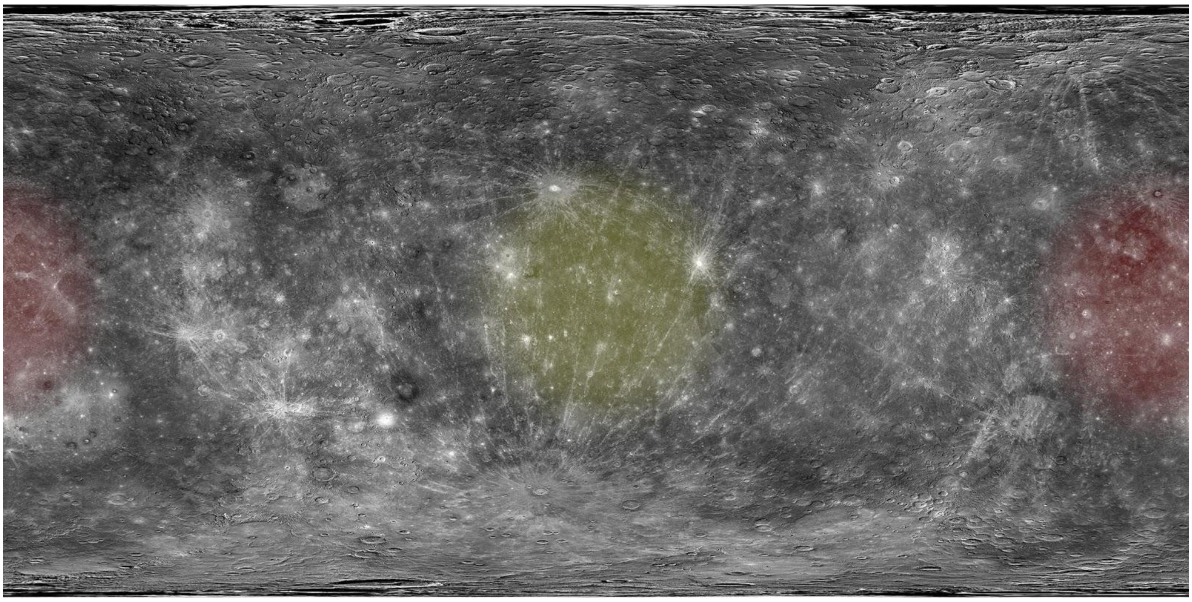


Fig. 3: Identification on Messenger's global map of Mercury of the locations of the observations depicted in Fig. 1 (red shading) and Fig. 2 (yellow shading).

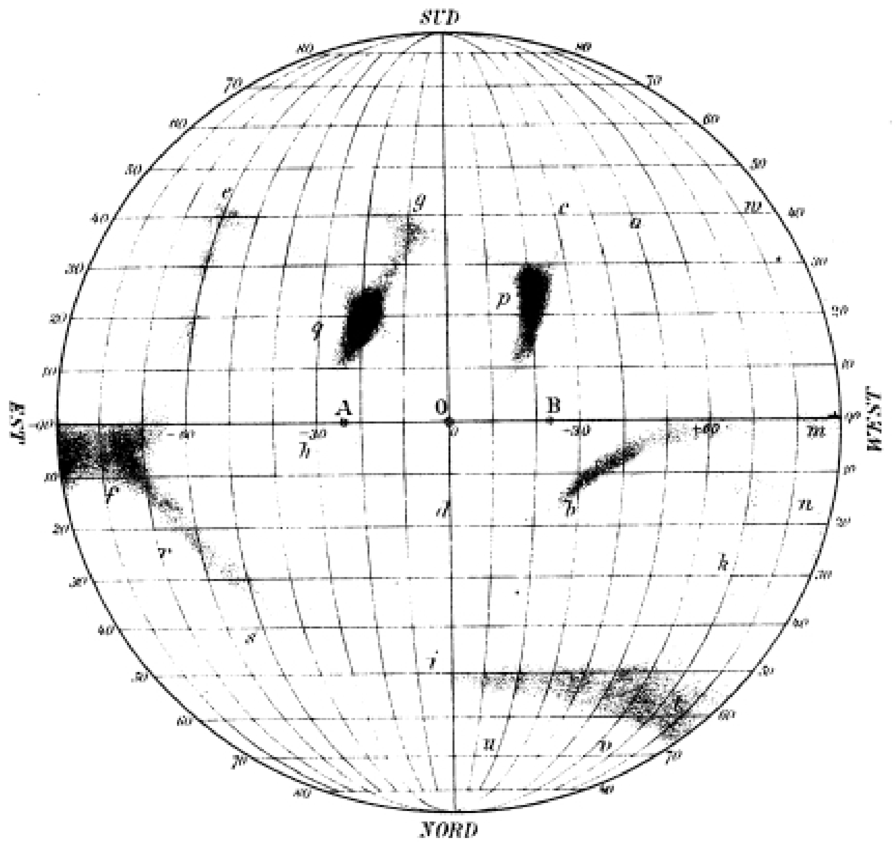


Fig. 4: Planisphere map of Mercury in Schiaparelli, 1889b.

exactly (which would require identifying the same spots from in successive elongations, after some time in which the planet isn't observable) he believed he could identify as a single spot what are in fact different structures on the planet's surface, sometimes greatly distant from one another, but with a similar appearance. From this, he deduced that the rotation period of Mercury is equal to its revolution period, after being perhaps influenced by George Howard Darwin, who had shown how this condition was reached by natural satellites orbiting very close to their main planet. It is rather significant that the astronomers who observed Mercury after Schiaparelli have all confirmed his conclusions, at least until they were corrected in the 1960s by completely different techniques (radar measurements from Earth and space probes); this came as a great surprise to those in the field of celestial mechanics, who had never encountered a similar case.

Appendix 1. Schiaparelli's poem

Contrary to Cynthia's[2] example, the Cyllenian[3] axis
Maintains an eternal night and an eternal day;
One of the sides is perennially burnt by heat,
The other, hidden in darkness, wants the Sun.

You will no longer be so amazed by torrid Tabropane[4],
Which is tormented by the blazing Titan[5] with his rays,
Nor the frostbitten Riphean mountains[6],
Nor Thule[7], oppressed by the night of the North pole.

A moon which with great contrast indeed burns and freezes,
For what you call months are days for her;
A much unhappy star, that which revolves in the first orbit,
Trapped by a great flame and a great frost.

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[2] Another name for Venus.

[3] "Of Mercury"; the god Hermes was, in Greek mythology, said to be born on Mount Cyllene, in the Peloponnese.

[4] A semi-mythical tropical island described by ancient Greek authors, often identified with Sri Lanka.

[5] Helios, the divine personification of the Sun in Greek mythology, was one of the gods known as Titans.

[6] A mythical mountain range located near Hyperborea, in the very far north of the world according to ancient Greek geographical notions.

[7] A mythical island located in the far north of the world according to ancient Greek geography.

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