Mem. S.A.It. Vol. 82, 209

Memorie della

Schiaparelli and his legacy

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Abstract. Giovanni Virginio Schiaparelli has been one of the most important Italian astronomers of the eighteen hundreds. He was an active scientist and the director of the Brera Observatory for close to 40 years; his scientific achievements and his personal influence can be traced to a very large community of people and subjects, which go well beyond the observations of Mars, for which he is most famous. His vast range of interests, which include studies on history of Astronomy and ancient languages, Solar System bodies, meteorology, and Earth sciences, are well documented and will be the reviewed in this conference. More relevant to modern science, he has left us a very solid legacy, both with his pioneering scientific works, now progressing with new discoveries and the aid of new technology, and with the consequences of his observations of Mars, which have greatly influenced the literary world and have opened new research activities in medicine.

1. Introduction

With this contribution, we briefly review Schiaparelli's life and achievements in the context of modern science and technology, in order to highlight specific papers that are part of this volume, and touch upon a few aspects that have not been specifically reviewed. We hope that this will prove useful, in particular to those who could not attend the conference.

2. A brief excursus on Schiaparelli's early life

At the time of Schiaparelli's birth, Italy was not a nation yet, so he was born under the "Regno di Sardegna" and the king Carlo Alberto di Savoia. Although he came from a poor family of tile-makers, he received a higher education,and was admitted at the prestigious Royal University of Torino at the young age of 15. Here he had extremely talented and influential teachers who both formed his scientific mind and helped him throughout his career, while serving in the government of the new-born Italian Kingdom (for a more detailed account on his life, see Ferrari 2011).

His lifelong passion for astronomy, which he developed very early in life , is at the base of many of his choices: his determination to learn both modern and ancient languages, to better comprehend the astronomy of the Sumerian and the astronomical contents of the Bible and to correspond with his contemporaries; his early resignation from his teaching duties at the Gymnasium "Porta Nuova" in Torino, where he was hired to teach elementary mathematics; his comments later on in life, e.g., about the astronomer's duties in meteorology; even his neglect of his duties as Senator of the new-born Italian Kingdom, which would take time from his precious observations.

With the aid of one of his teachers and supporters, Quintino Sella, he could soon satisfy

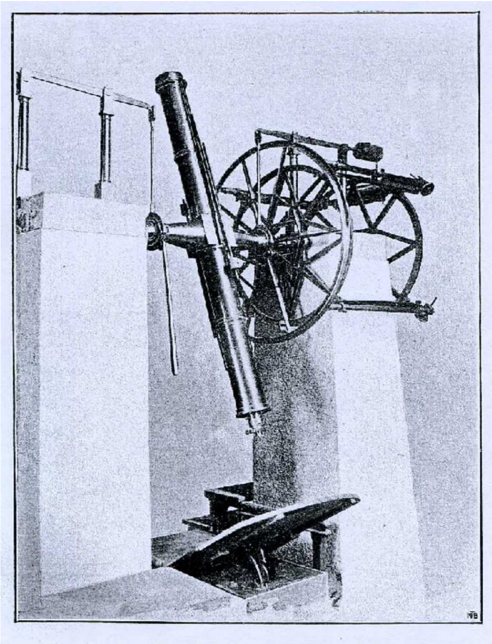


Fig. 1. Meridian circle by Starke, after modification in 1874 (from an illustration in "Omaggio all'Astronomo G.V. Schiaparelli (1900)"). The instrument is now lost.

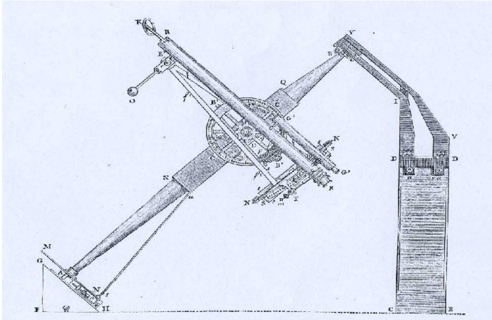


Fig. 2. Equatorial sector by Sisson (from an illustration in "Omaggio all'Astronomo G.V. Schiaparelli (1900)"). This instrument is part of the collection of instruments of the Brera Observatory and is on display at the Museo Nazionale della Scienza e della Tecnologia in Milan.

his desire to dedicate himself to astronomy: he obtained a grant from the government to study abroad and, at the age of 22, he was sent to Berlin. He wrote a very detailed account of that period (Tucci 2011). A few years later he went to the Observatory in Pulkovo (Abalakin 2011) where he was initiated in observational astronomy, under the guide of O. W. Struve and F.A.T. Winnecke. At the age of 25, he had already accumulated enough experience and skills to open his mind to a broad view of science that characterized his entire life. It is hard to envision such a high quality education under so prestigious teachers even in these modern time of air travel and Internet!

This experience, coupled with the new political events in Italy, brought him to the Osservatorio Astronomico di Brera, in Milano, where he spent the rest of his scientific life.

While in Milano, his activities included teaching duties, both at the newly founded "Istituto Tecnico Superiore", now known as the Politecnico, and the University of Pavia. But he soon stopped: he was much more inclined to correspond with his peers to share results and discoveries (which is shown in the rich correspondence with many of them) than to teach students.

3. Observing without a modern telescope

Upon his arrival at Brera, in 1860, he was faced with a run-down Observatory, equipped with limited and old instruments. He soon was able to order a modern instrument, a 22cm refractor from the German constructor Georg Merz. Before it became operational, though, Schiaparelli started his life at the Observatory using the "Circolo Meridiano" made by Starke (Fig. 1) and the "equatorial Sector" by Sisson (Fig. 2), which were operational at the time. With the Sisson he soon discovered "Esperia" (an old Greek name for Italy), a new asteroid later named (69) Hesperia, and for which he correctly reproduced the orbital elements (Fig. 3).

In his early observing diaries, several drawings of comets testify to his interest in the direction of their tails and in their motion.

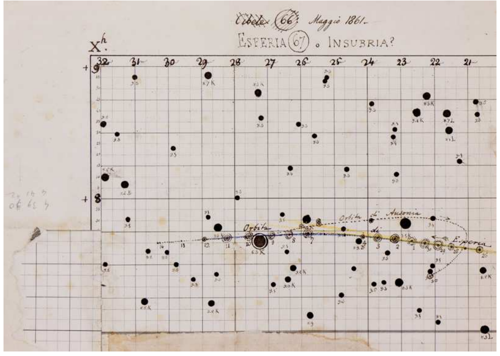


Fig. 3. Original design that Schiaparelli made while observing with the "equatorial Sector", that led to the discovery of *Esperia* (from the Archive of the Osservatorio Astronomico di Brera).

The appearance of the comet "Swift-Tuttle" in 1862 prompted him to systematically study comets. In his correspondence with P. Secchi (Maffeo 2011) he debates with his colleague in

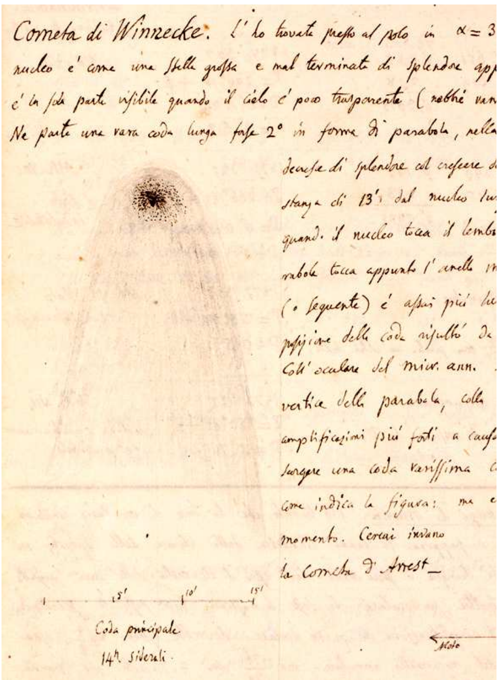


Fig. 4. Winnecke comet in Schiaparelli's diary. 13 may 1877. Archive of the Osservatorio Astronomico di Brera.

the Collegio Romano on the controversial nature of the origin of shooting stars, and demonstrates their relation to comets. In particular, he demonstrates that the orbit of the Perseid meteor shower is the same as that of the 1862 comet he had been observing. Similarly, the Leonids observed in 1866 could be associated with another recursive comet named "Tempel-Tuttle".

With somewhat obsolete instrumentation, at the age of barely 30, Schiaparelli made his most fundamental discovery, providing an explanation of an astronomical event that still holds today: meteors are debris of comets left along their orbits, that become visible in the form of a meteor shower when their orbit intersects that of the Earth. Even today, many years after his discovery, the search for parent bodies of meteors is not over yet (see Jopek 2011).

Although his main interests soon changed, he never abandoned comets and meteors: he published several catalogs of shooting stars, beginning with that of 1867; he discussed the great meteor shower he observed in 1872; he left a record of all comets visible from Milan up to 1894 (Fig. 4). In 1908 he picked up the subject again and discussed orbits, currents and meteors, advancing a first suggestions on the origin of comets themselves that would then be fully developed by Oort half a century later.

He also used his time to write the "Memorie classiche", where he describes distances and magnitudes of celestial bodies according to Copernicus's precursors ("I precursori di Copernico" in 1873) and the view of the dimension of the Universe in ancient times ("Le sfere omocentriche di Eudosso, di Callippo e di Aristotele" in 1875). These researches were of course based on documents that he could read in the original version, be it Greek, Assyrian or cuneiform (see De Meis 2011): how could he trust translations? He needed to consult parapegma (an old type of calendar that would indicate the relation between astronomical and civil or meteorological events), knew about the progress that the Babylonian Astronomers had made, discussed the astronomical references in the Old Testament, all based on original sources (Antonello 2011).

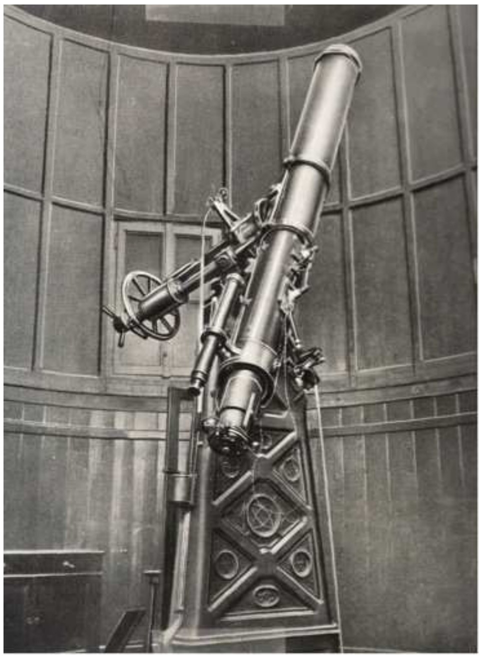
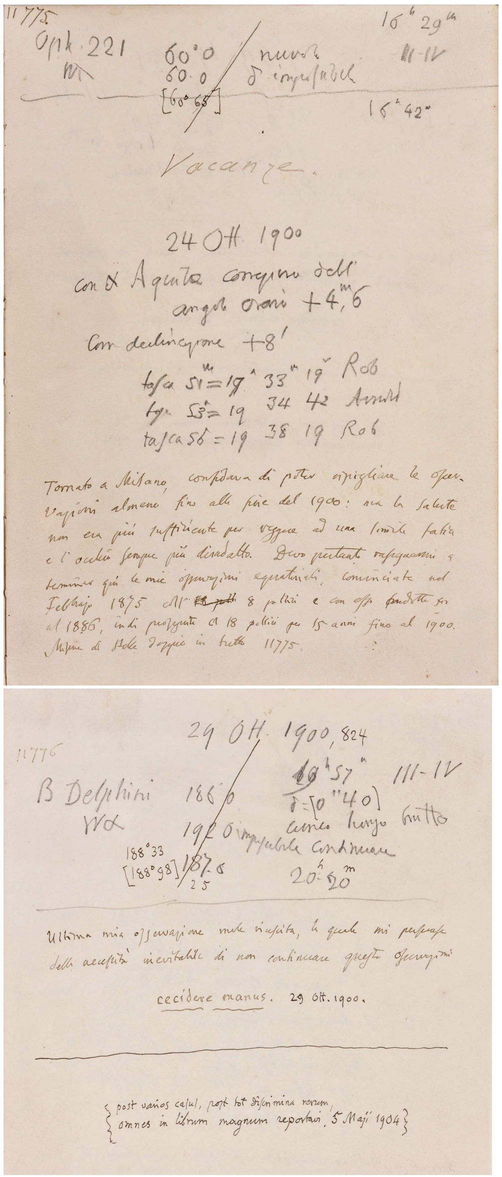


Fig. 5. The 22cm Merz refractor at Brera.

4. Mertz refractor: 22cm

When the renovations to the dome to include the new telescope were finally over, Schiaparelli started micrometric measures of the position of double stars with it (Fig 5) and recorded 10958 measures relative to 1101 double systems! His last measurement of double systems is also the last observation he ever made: after a poor performance, on October 24^{th} 1900 he declared, unwillingly but resigned, that the time had come for him to stop observing, an activity he had done for 40 years in Brera (Fig. 6).

The new telescope brought however an unexpected twist to Schiaparelli's life, when he decided as a diversion to test the optical properties of the new refractor and pointed at Mars: this decision was going to transform his life and career, and opened a new successful line of research.



Vacanze.

24 Ott. 1900

con α Aquilae congiunto dell' angolo orario +4m,6

Con declinazione +8'

Tornato a Milano, confidava di potere ripigliare le osservazioni almeno fino alla fine del 1900: ma la salute non era più sufficiente per reggere ad una simile fatica e l'occhio sempre più decaduto. Devo pertanto rassegnarmi e terminare qui le mie osservazioni equatoriali, cominciate nel Febbrajo 1875 coll' 8 pollici e con esso condotte fino al 1886, indi proseguite col 18 pollici per 15 anni fino al 1900. Misure di Stelle doppie in tutto 11775.

29 Ott. 1900

β Delphini

Ultima mia osservazione male riuscita, la quale mi persuade della necessità inevitabile di non continuare queste osservazioni

cecidere manus. 29 Ott. 1900.

{post varios casus, post tot discrimina rerum, omnes in librum magnum reportavi. 5 Maji 1904}

Fig. 6. Testimony of Schiaparelly's last observation: *"cecidere manus. 29 Ott. 1900"*. From Schiaparelli's diaries, Archive of the Osservatorio Astronomico di Brera.

5. Mars!

Maps of Mars were already available at the time: 18 drawings published by Padre Secchi in 1859 and the map by Proctor in 1877-78

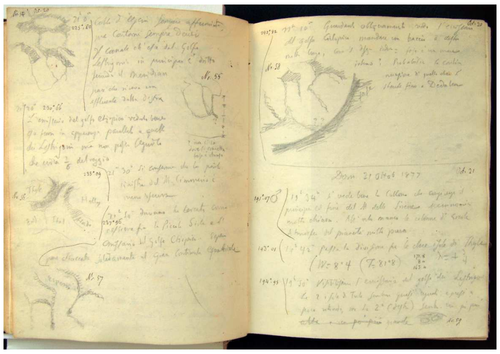


Fig. 7. A drawing of Mars in Schiaparelli's diary in October 1877. From "Le Mani su Marte", Archive of the Osservatorio Astronomico di Brera.

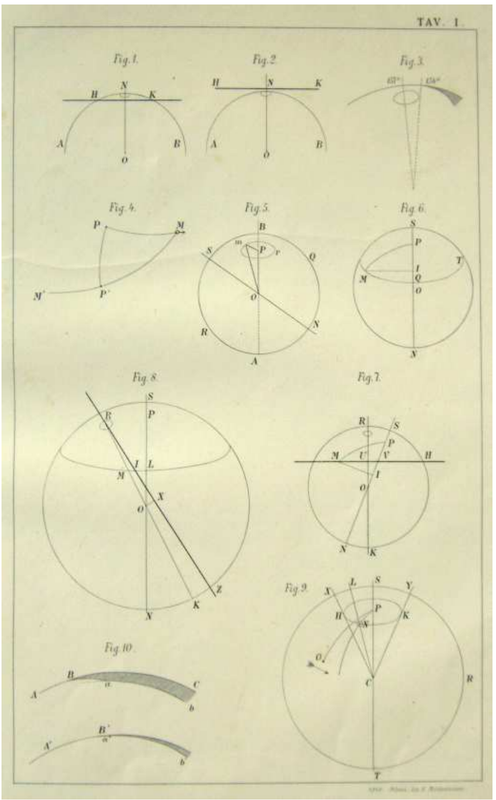


Fig. 8. TAV.I published in the first "Memoria" in 1878. From "Le Mani su Marte", Archive of the Osservatorio Astronomico di Brera.

were showing structures, such as long features ("canali"), "continents", "seas" and white polar caps, where Herschel had seen evidence of ice. However, the high quality of the image of Mars that Schiaparelli saw through the telescope showed him details he did not expect!

He immediately set to study this planet (Fig. 7) and applied his training and experience as a geographer to study Mars with "geometrical methods and principles" (his words), applying cartographical methods to Mars topology: *aerography* was born. He used micrometric measures of 62 locations on the surface of Mars to determine the axis of rotation (Fig. 8) and to draw new maps of the planet , which gained in details and complexity (see Fig. 9) also thanks to the second, larger refractor, which became operational in Brera a few years later. He used latin and mediterranean place names taken from ancient history, mythology, and the Bible to describe the dark areas, the "seas", and lighter areas, the "continents".

Mars became soon a popular target, and "canali" were seen by several observers, who also contributed to suggest the idea that they were built by a supposedly intelligent civilization. Among them was Percival Lowell, who devoted more than ten years to study Mars and identify new canals (Manara & Wolter 2011).

Today we know that most of the details he saw are not real, most likely artifacts or "optical illusions" (see Berlucchi 2011; Sheehan, Boudreau & Manara 2011): space images do not show the canals that were seen at the time (Coradini & Orosei 2011), nor their splitting, the "gemination" phenomenon. Even larger telescopes used for example by Cerulli and Antoniadi at the time of Schiaparelli had already undermined the reality of "canali" on Mars. But Schiaparelli didn't change his mind until the end – and although he never promoted life on Mars in his scientific work, he remained convinced of the existence of "canali" on Mars, whatever their origin.

6. Finally a larger telescope: Merz-Repsold, 49cm diameter.

Italy was becoming a nation, Rome was now the capital of the new Kingdom of Italy. Times were hard: life expectancy was 33, mostly

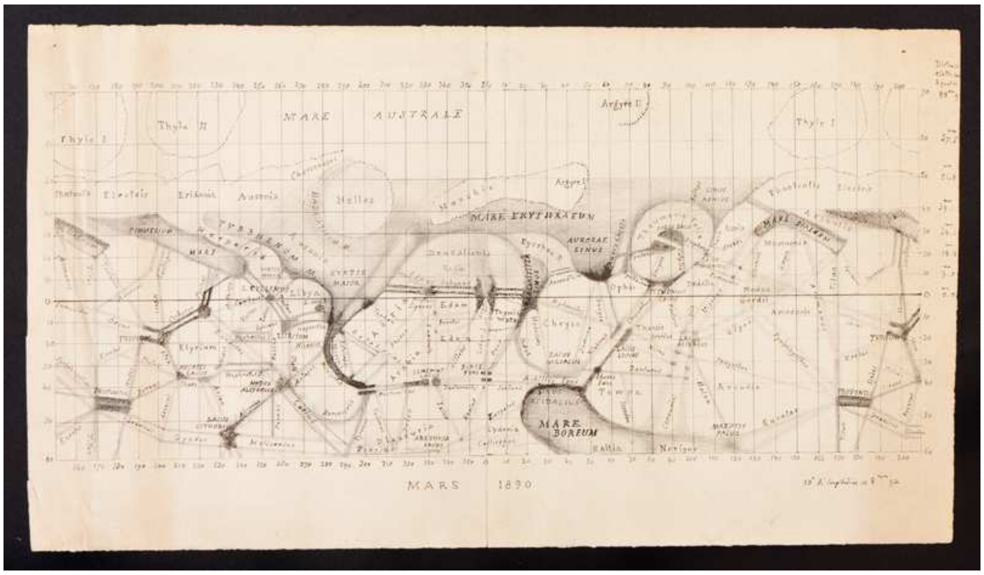


Fig. 9. Map of Mars based on drawings taken during the opposition of 1890. Archive of the Osservatorio Astronomico di Brera.

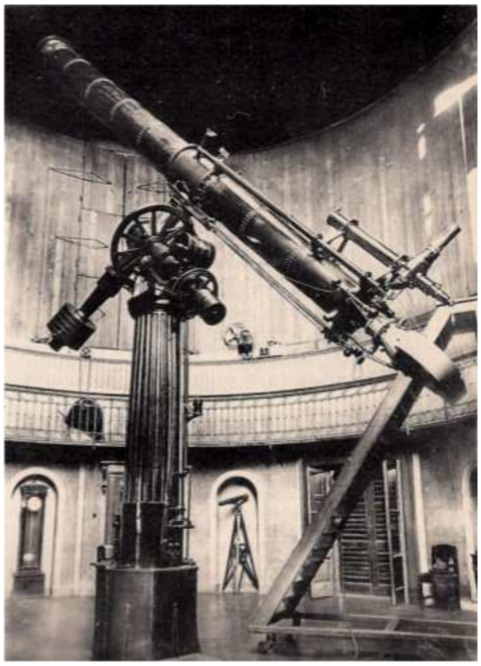


Fig. 10. The 49cm Merz-Repsold refractor in Brera

due to a very large infant mortality; the economy was anything but blooming, emigration to the United States, Brazil, Argentina, was large, food was scarce, prices for bread and pasta were artificially high and wool was a luxury. And yet, efforts were made to encourage technology, industry and culture: National and World expositions were held, the *Funicolare del Vesuvio* started operations in 1880, the first train traveled through the new *San Gottardo* tunnel to Switzerland. It is in this climate that the Italian government approved funding of 250.000 Lire for a new telescope for Schiaparelli in Brera (Fig. 10). In a note written in haste from the "Camera dei Deputati" (Fig. 11), Quintino Sella, former minister of Finances and among the proposer of the infamous "tassa sul macinato"[1] gives Schiaparelli the good news that the Parliament has approved the requested funding.

With the Merz-Repsold (Fig. 10), Schiaparelli could now resolve double stars with unprecedented precision, look at Mars and confirm the "gemination" phenomenon;

[1] grist tax

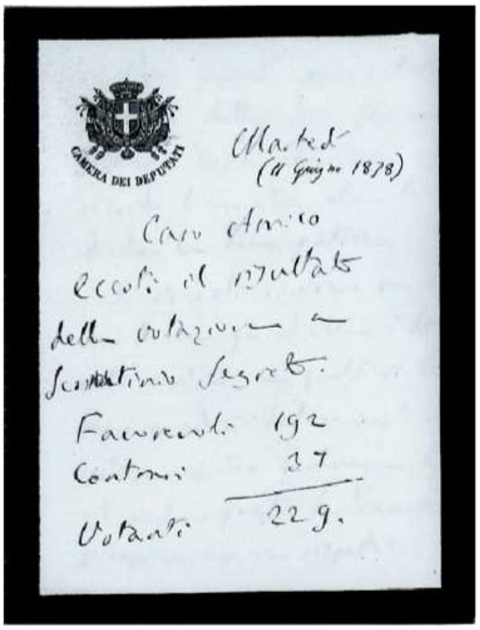


Fig. 11. First page of the letter from Sella congratulating Schiaparelli on the new telescope. From the Archive of the Osservatorio Astronomico di Brera. *"Caro Amico eccoti il risultato della votazione a scrutinio segreto. Favorevoli 192; Contrari 37; Votanti 229. La votazione è veramente splendida e negli uffici e nella Camera si disse esplicitamente che si dava il canocchiale perchè vi era un astronomo che lo valeva. La stima che si ha di te ci entrò per moltissimo nel voto. Puoi quindi essere lieto e fiero della dimostrazione solenne tanto che non ne ricordo l'eguale, che ti diede la tua patria. I 37 voti contrari non eccedono che di una quindicina i soliti voti contrari a qualsiasi legge. Sono quindici determinati a votare contro qualunque spesa, ed anche questo sentimento si capisce e va rispettato"* [namely: "Dear friend, this is the result of the secret ballot: 192 in favour, 37 against, 229 voters. You should be proud of this result: this funding is approved only because it is known that a worthy astronomer will use the telescope. This is an unprecedented high tribute from your country. The 37 votes against it are about 15 more than usual: they come from a small group determined to vote against any expense; we should understand and respect also this point of view.]

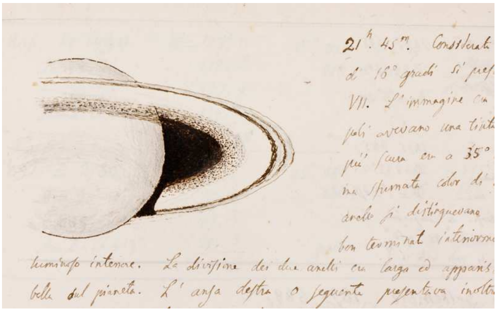


Fig. 12. A drawing of Saturno. From Schiaparelli's diaries, at the Archive of the Osservatorio Astronomico di Brera.

he explored the boreal region of Mars, which he could not do with the smaller telescope.

However, while Mars was and still is the most discussed by far of his research activities in many respects, it was not the only planet he observed nor the only one for which his studies were scientifically relevant and successful: he tried to understand the form of Jupiter's satellites, although he did not come to a satisfactory conclusion, and observed Saturn (Fig. 12) and Uranus repeatedly, as can be seen in his publications (see, for example, Schiaparelli 1863, 1883b and Schiaparelli 1883a, 1884).

Among his successes (see details in Sheehan, Boudreau & Manara 2011), he proposed that Mercury is in synchronous rotation about the Sun with a rotation and orbital periods of 87.97 days (Schiaparelli 1889, see also Flamini 2011). This original idea was confirmed by data from other observers (Danjon 1924; Antoniadi 1934). Though we now know that the rotational period is incorrect, it took over 60 years to disprove it! In fact, it was only thanks to Earth-based radar measurements and subsequent work by Colombo (1965) and Colombo & Shapiro (1966) that the rotation period was later measured to be about 2/3 of its period of revolution.

His systematic observations of Venus (Fig. 13) led Schiaparelli to formulate a definite theory on this planet. He had already concluded that its period of rotation was longer than the $\sim 24h$ period suggested at the time. By 1890, he was ready to conclude that Venus makes one rotation in 224.7 days, which is

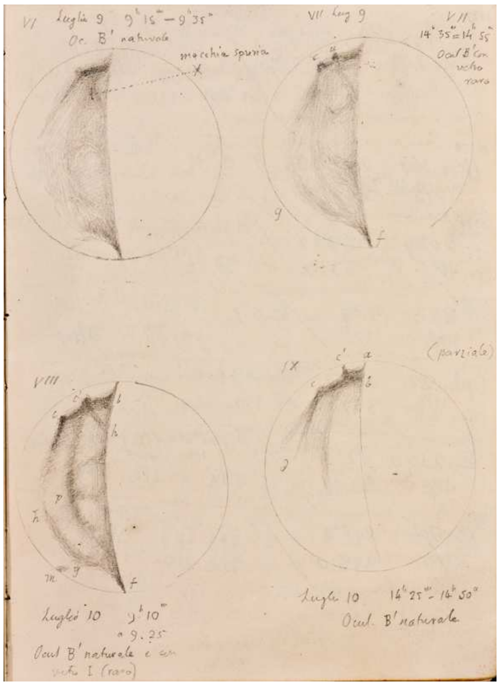


Fig. 13. Venus in Schiaparelli's diaries. From the Archive of the Osservatorio Astronomico di Brera.

the period of its sidereal revolution around the Sun, about an axis very nearly perpendicular to the plane of the orbit (Schiaparelli 1890). It would again take a long time to realize that he was actually wrong (Dyce 1967) and that Venus has in fact a "retrograde" rotation about the Sun! In fact, the exact value of Venus' period is still a subject of discussion among scientists in today's meeting on planetary science (e.g. "X Congresso di Scienze Planetarie" in Bormio, Italy).

7. Meteorology

Research on meteorology and geomagnetism should be listed among Schiaparelli's duties rather than his interests; nonetheless his contributions are important, as testified by Giovanni Celoria in his commemoration (Celoria 1910).

Schiaparelli was conscious of the relevance of the long series of observations that are a patrimony of Brera, and of the importance of this discipline. His objection was apparently to who/what kind of institution should devote time and energies to such a science: meteorology should have its own research center, with adequate instrumentation, and it should be part of a larger consortium in a world-wide database. Astronomers are not the proper scientists for this job.

In this respect, we see Schiaparelli in his role of director of a research institute: with limited resources and personnel, meteorology represented a lot of additional work, both to maintain the complex instrumentation and to use it at the appropriate times (mostly during the day, but also at dawn and at night) and in the correct way. Not to mention a proper interpretation of the data! Time, personnel and resources that could not be allocated to astronomy.

It is interesting to note, though, that in spite of his apparent dislike of this discipline, he embarked on a series of scientific discussions and papers on climate, meteorology and even the influence of the Moon on the Earth's atmosphere. Moreover, he provided the observatory with new instruments, so that, in his own words, the Observatory would not lag behind, but could progress further in excellence.

8. Astrophysics

What was the true feeling that Schiaparelli had towards this new discipline? Many suggest that he was strongly opposed to it (see for example Bianchi, Galli & Gasperini 2011). However, in his presentation to celebrate Schiaparelli's career, Bianchi (1935) claims that an accurate reading of his studies on shooting stars and on planets indicates that he recognized the need to integrate classical astronomy with physics, just as much as Angelo Secchi did. While it is true that he did not apply himself to spectroscopy, it is likely that Schiaparelli was not ready and felt inadequate, probably as a result of his very classical upbringing (both in Berlin and in Pulkovo), and preferred to leave this new scientific approach to his colleague and friend "maestro" Secchi, an expert in the field with whom he had a rich correspondence on several aspects of his research.

9. Minor contributions (really minor?)

We can list a series of subjects in which Schiaparelli was interested and gave his contribution. Besides astronomy and meteorology, of which we have already spoken, he worked on the motion of the terrestrial poles and Earth rotation (Scalera 2011), geodesy and geophysics, mathematics, optics, geo-magnetism. Many essays in these subjects were written with the idea that they could be useful to teach and disseminate scientific knowledge and culture.

He was also intrigued by the structure of the Universe: could William Herschel be right? He had two simple hypothesis: the observed stellar density was a measure of the depth of the Universe and the brightness of the star was a measure of its distance. In his first recorded discussion on the subject, in 1863, Schiaparelli optimistically accepted these as viable hypothesis, but 26 years later, in 1889, he was ready to dispute them: how was it possible to reconstruct dynamics and geometry of the Universe without a proper knowledge of fundamental observables, such as proper motion, radial velocities and parallaxes of stars? They should be first properly understood, and then applied to reconstruct the structure of the Universe.

10. Medals, awards, academies ...

The relevance of Schiaparelli's work and discoveries gave him fame and recognition worldwide (see, for example, the recognition he obtained from French astronomers by Débarbat 2011). He was awarded numerous medals and prizes, and became member of probably as much as 48 prestigious academies and societies, in Italy, France, in the UK and in the US (for a detailed list of the academies, medals and prizes, see Mazzucato 2010).

In 1889 he was nominated Senator of the Italian Kingdom. It is interesting to note his reaction to this honor and that he went to take his seat at the Senate only in 1898! In a letter to P. Boselli, Minister of education, he expresses his doubts about this nomination: he states that, while extremely honored and grateful for this honor, what Italy needs is [his words] *the right man in the right place* – and he would not be such a man. He would better serve and honor his country by making good use of the new telescope that had costed Italy so much money!

11. His legacy

With the exception of the theory on the origin of meteors (Jopek 2011), all of Schiaparelli's conclusions have been revised, new data have indicated different solutions and new explanations for the same phenomena he studied have been put forward. This is the beauty and strength of science!

Our knowledge of the Solar System, its planets, comets, asteroids has improved considerably in the last century. New observations and better quality data have become available. Technology has given us unprecedented means for space exploration of the Sun and the Solar System (Antonucci 2011; van Casteren & Novara 2011; Messidoro 2011; Boggiatto & Moncalvo 2011; Chiocchia & Vallerani 2011; Gardini 2011; Perino 2011; Svelto 2011; Trucco, Pognant & Drovandi 2011). Combining space data with "more traditional" observations, we can now discover exoplanets (Lunine 2011), study asteroids even *in situ* (Cellino & Dell'Oro 2011), analyze and probe the surface of Mars (Lupishko, Kaydash & Shkuratov 2011; Giorgio 2011; Coradini & Orosei 2011; Perotti & Rinaldi 2011).

Nonetheless, the relevance of what he achieved, the quality of his results, his dedication to his work deserve full credit. We are by no means the first to celebrate Schiaparelli. In 1900, all astronomers around Italy published an "Omaggio" to celebrate his 40th year in Astronomy, which included a very detailed history of his scientific life and the complete bibliography of his scientific works. Ten years later, upon his death, he was commemorated by colleagues and friends all over the world. Now, one hundred years later, we are here again, to celebrate this towering figure and to continue his work.

But we also need to acknowledge another aspect of his legacy: thanks to his probably faulty vision and his personality we have seen Mars as a land of canals, seas, mountains, which was instrumental in providing us with many delightful stories about its presumed inhabitants and a rich science fiction literature. Of course we know that Martians do not exists! Nonetheless, the quest for *"life"* on Mars is still ongoing, and involves a wealth of data collected from past or current science missions, and future ones that are already being planned (such as EXOMARS, and see Rizzo & Cantasano 2011). New theories to explain the behaviour of the eye under specific conditions (Sheehan, Boudreau & Manara 2011) have prompted a new line of investigation. And medicine and neurology have also made progress in understanding the relation between vision and our brain (Berlucchi 2011).

Thank you, G.V.S.!

Acknowledgements. We are very grateful to all who have supported and encouraged us during planning and organizing of the series of events, of which this meeting is an expression. All speakers and participants have been very supportive and have enthusiastically contributed to the success of this meeting and we thank them wholeheartedly. We also thank L. Buffoni for providing us with the results of her work, M. Carpino for his photos, A. Mandrino for her assistance.

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