Mem. S.A.It. Vol. 82, 232

Memorie della

Between two Halley's comet visits

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Abstract. An outline the scientific contributions of Giovanni Virginio Schiaparelli in the years of transformation from classical astronomy to astrophysics.

1. Introduction

"On a clear night of the late fall of 1839 my father was going back home after checking the fires in his furnace; I had obtained permission to accompany him during this nocturnal journey. Due to the late hour and the total darkness, I was falling asleep. Then my father took me in his arms and to keep me awake began to tell me about the constellations. In this way, at four I learned how to recognize the Pleiades, the Big and the Little Dipper, and the Milky Way that my father called the Saint James Way. Suddenly a falling star flashed in the sky, and then another, and another. I asked what they were and my father replied that such things were only known to God Almighty. I was left without words, conquered by a confused sensation of incommensurable and adorable things, immense in space and time."

This is the account by Giovanni Virginio Schiapparelli himself of the early beginning of his interest in astronomy. And again from his memoirs. *"In the early morning of the 8th of July of 1842, while I was waking up, my mother burst into my room shouting: "come, see the eclipse!". I quickly put on my trousers and looked out of the window: it was the very moment of the total occultation of the solar disk ... In my shool book I had read about the fact that sometimes the moon hides the sun and brings complete darkness in the middle of the day. Now I was indeed seeing the moon as a black disk covering the sun, surrounded by a beautiful halo. After following the various phases of the phenomenon, I wanted to keep memory of the event by drawing a color picture. And my amazement grew even more when they told me that men existed who could predict such phenomena by the day, hour and minute. It was at that moment that in me the desire arose of becoming one of those men and the daring ambition of sharing the determinations that govern the universe".*

2. Schiaparelli the scientist

Schiaparelli was born on the 14th of March of 1835, a year marked by the passage of the Halley's comet at perihelion; an event he could not see, while his mature scientific life would be dedicated to the study of comets. His native town was Savigliano, in Piedmont, Italy, where his father operated a furnace to supply bricks for the constructions of the king of Piedmont and Sardinia in Turin. A worker at the furnace, Miglietti, an amateur astronomer,

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gave Virginio his first book of astronomy, *Notizie astronomiche adattate all'uso comune* by Antonio Cagnoli of Modena.

At the age of 15 Schiaparelli enrolled in the University of Turin choosing the studies of engineering. He graduated in civil engineering at 19, with a good training in drawing and cartography that he will later use in mapping the skies. At the same time he continued his self-taught studies in astronomy on one of the most advanced books of the time, Astronomia by Giovanni Santini of Padua. The priest of Saint Mary in Savigliano, also an amateur astronomer, could provide Virginio with a small spyglass to observe sunspots, Venus phases, Jupiter's moons, Saturn's rings, the Pleiades and nebulae: the result was a chart of the stellar region around the constellation of Pegasus, his first experience in cartography. Also he built a sundial on the south faade of the Saint Mary church that still exists today.

In order to read the most advanced books of astronomy Schiaparelli rushed to learn German, as Germany was at the time the leading country in science and culture; thus he became acquainted with the works by Maedler, Littrow, Struve, Encke, Gauss, Bessel, Schroter, Olbers, Helmholtz, Humboldt. With this cultural background he approached Giovanni Plana, the director of the Astronomical Observatory of Turin and famous for his work on the theory of the lunar motion, with the hope to become his assistant. However Plana had to turn down the offer due to the lack of positions at the Observatory. The refusal did not discourage Schiaparelli who engaged himself in the calculation of the orbit of a comet observed in 1556. He sent the results to his former professor of mathematics who was so impressed that brought Schiaparelli's case to the attention of senator Carlo Ignazio Giulio; by his support Schiaparelli was granted a fellowship by the Ministry of Public Education of Piedmont and Sardinia to study in Berlin. It is important to remark that in those years the movement for the unification of Italy had chosen the king of Piedmont and Sardinia as its leader; it was in the plans of the king and his ministers to foster the creation of an intellectual class of international level.

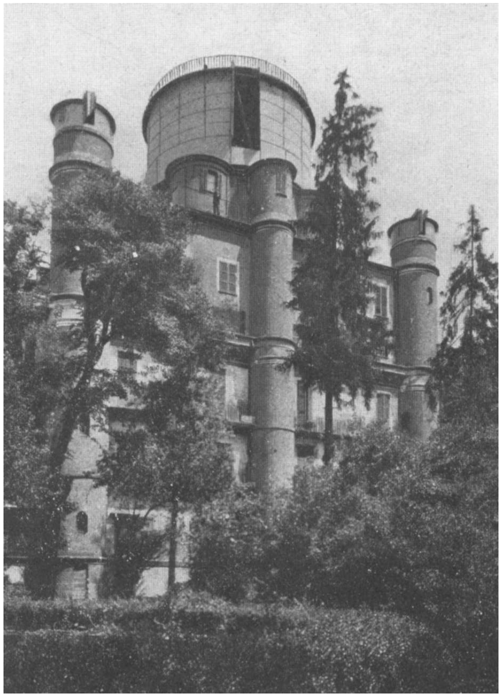

Fig. 1. Brera Observatory in 1859

On the February of 1857 Schiaparelli left to Berlin and in two years of hard work absorbed the most advanced research techniques in modern astronomy and learned the methods to investigate empirical phenomena and to represent them in theoretical models. At the time Berlin was the leading cultural centre of Europe and the world, inspired by the education program introduced by Wilhelm and Alexander von Humboldt: science interprets the book of nature and with its methods can also fruitfully approach human and social disciplines. Along this line Schiaparelli studied sciences related to astronomy, as mechanics, optics, magnetism, meteorology, but also other disciplines as philosophy, literature, history of religions, history of ancient astronomy. He learned several languages, russian, greek, arab, in addition obviously to english, french and german. He developed a strong interest for historical investigations and a pleasure for erudition. In June of 1859 Schiaparelli moved for several months to Saint-Petersburgh where he worked at the Pulkovo Observatory with Friedrich von Struve. Finally at the end 1859 he returned to Italy at took a position of astronomer at the Brera Astronomical Observatory in Milan; Milano and the Lombardy had been annexed to the kingdom of Piemonte and Sardinia the previous June. The director of the Observatory was Francesco Carlini; after his death in 1862 Schiaparelli became director himself under the newly founded kingdom of Italy. In fact he made himself known to the reunified nation with the discovery in 1861 of the asteroid Esperia, that he named after the ancient name of Italy. With his rich cultural background, Schiaparelli became an important figure in the intellectual circles of the Italian Milan, friend of Cremona, Casorati, Porro, Stoppani. While observing at night he could also teach geodesy in Milano and later astronomy in Pavia.

His most important works in the period were accurate observations that allowed him to complete statistical studies of the distribution of stars in the Milky Way; he derived a theorem to calculate the spatial density of stars that brings his name. These observations were very demanding, as he describes in his memoirs in which his hard working habits become apparent. *"In my robust years, from 25 to 60, I usually worked ten hours a day ... when I planned to observe I did not have dinner, but slept a while before going up to the dome as I felt necessary to have a fresh mind and clear eyes, in order to make good observations. To such practice I attribute the success I had in some of mine more difficult observations."*

He was always very careful and precise in presenting the results of his work, avoiding any complacency and self-celebration. *"I must say that my work has never been of one quality. I divide work in "active", that is meant to produce something, like observations, calculations, writing scientific papers ... and "passive", that is functionl to prepare the other, and consists in reading or studying; because in astronomy, as in many other activities, in order to sell one has to buy first ... The work of an astronomer consists in making observations, calculate them and publish the results. This is done by short communications, referring clearly and concisely what has been obtained, without any eloquent effort or specific literary genius".* The sector in which Schiaparelli brought his most important and lasting contribution is the study of meteors, popularly called "falling stars", the very phenomenon that had attracted his attention when a little kid. Scientific opinions about meteors were at the time very vague, as little was known about their nature, dimensions and origin. Neither was clear their connection with the meteorites that fall to earth with results sometimes disruptive when of great size. Schiaparelli began to collect data on the arrival directions and speeds of meteors, also observed by himself. He could then calculate their orbits and deduce that they followed very elongated elliptical orbits similar to those of comets; in particular periodic meteor showers, as the Perseids illuminating the sky around August 10, have common orbits. Combining these data Schiaparelli discovered that meteor showers follow the path of extinct comets. Therefore he concluded that pe-

Fig. 2. Leonids shower in 2001

riodic meteors are debris of comets vaporized by the solar radiation at perihelion. The result is a meteor trail of rocks and dust of different sizes along the comet orbit. Meteor showers occur when the Earth in its orbit around the Sun crosses the trail. Schiaparelli could in fact associate the Perseids (9-14 August) with the trail of the comet Swift-Tuttle and the Leonids (17 November) with the comet Tempel-Tuttle. The final proof was the 1852 observation of the Biela comet breaking in two parts and then dissolving completely. The theory was discussed in five letters to padre Secchi in 1886-87 and published in 1871 in the Astronomische Nachrichten.

In 1863 Schiaparelli inaugurated a campaign of observations of double stars, a subject that became a long term program of the Brera Observatory. The determination of the orbital period of double star is crucial to determine the mass of stars. The results of 11.000 observations of 1100 star systems were collected in two volumes published in 1900. Most of the work was done with a new 22 cm equatorial refractor telescope produced by the workshops Merz in Munich for which he had obtained a dedicated fund by the Italian government thanks to his personal prestige.

With this high-quality telescope Schiaparelli embarked also in planetary observations; in particular he took advantage of a favourable opposition of the red planet Mars in 1877 to explore and map its surface. The exceptional visibility and the perfection of the telescope optics allowed him to make progress in the definition of the rotation axis of the planet and its white polar caps. On September the southern emisphere of Mars was well oriented for the observations and Schiaparelli could map it with great accuracy: he started what he called "areography", the cartography of Mars. *"I intended to proceed in the description of Mars not depicting its portrait as it appears to the eye, but following instead a geometrical scheme ... in order to produce a map exactly as in our geographical maps, not to draw pictures imitating the appearance of the planet, but just to facilitate its description ... Previous astronomers who studied Mars through telescopes had already noticed two bright white spots, roundish and of variable extension. While other spots common on Mars move rapidly because of the diurnal rotation, changing every few hours on position and perspective, those two white spots remain stationary in their position ... [they must therefore] occupy the planet's rotational poles ... and may be designated polar spots and caps. We called instead Mars' dark spots "seas" and reddish spots "continents" ... One third of Mars surface belongs to the Austral Sea, filled with scattered islands and gulfs and ramifications stretching into the continents. The rest of the surface up to the northern cap is occupied by continents."*

The most sensational discovery, announced by Schiaparelli at the Lincei Academy on May, 5th 1878 with the long note "Osservazioni astronomiche fisiche sull'asse di rotazione e sulla topografia del pianeta Marte", were the "canali". *"The entire extension of the continents is ploughed in all directions by a network of lines or narrow stripes of dark color more or less pronounced, whose aspect is very variable. They run on very long distances on the planet with regular course, completely different from the meandering course of our rivers. These are "canali" and that they are ridges or depressions on the planet surface arranged for the flow of liquid masses, and represent a real hydrographic system, is proven by the fact that they became more visible when the polar caps recede."*

Schiaparelli named those structures "canali" simply associating their appearance with an expression used years before by padre Secchi. Later on however he became convinced that those dark lines were actually deep canyons as large as 100 km, where water was flowing and irrigating fields and forests that appeared in greenish colors in martian summers. He was proposing that they were natural structures and that interpretation appears clearly from his drawings and comments.

Schiaparelli reobserved Mars in 1879 during another opposition and discovered a small white spot that he imagined should be the top of a snowy mountain: he named it Nix

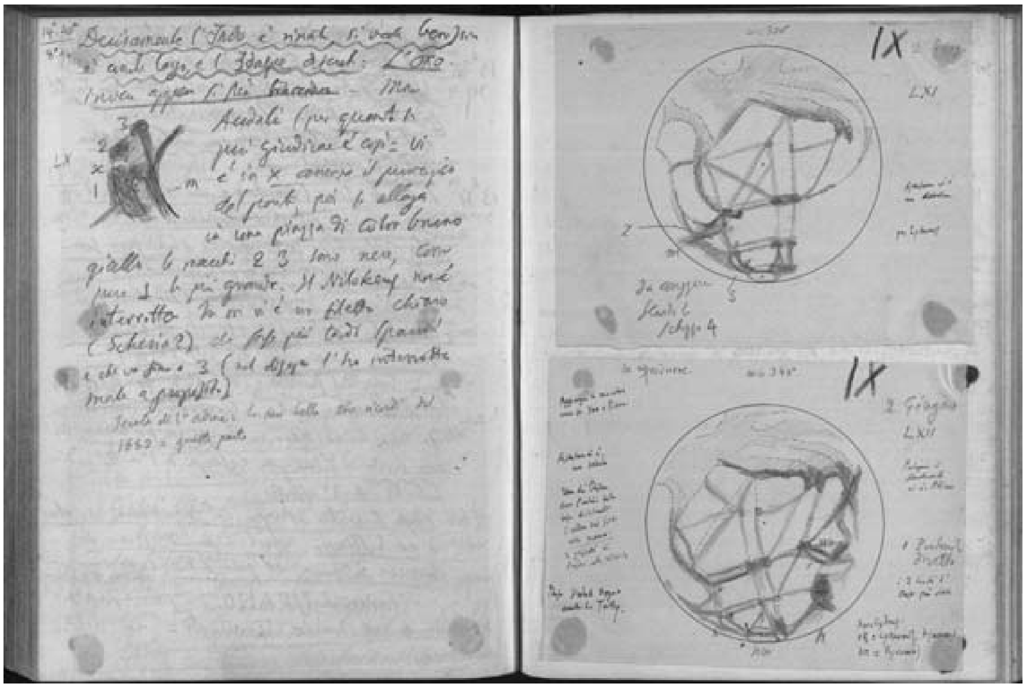

Fig. 3. Mars drawings in Schiaparelli's notes with "canali" and "gemination"

Olympica, Neve dell'Olimpo. We know today from the surveys of space probes that it is in fact the top of a gigantic dead volcano, 24.000 meters high. Further observations where made in 1881 and 1886 when Schiaparelli could announce another extraordinary phenomenon: *"The vast extensions called Ocean and Alcyonic Gulf, that in 1879 looked like uncertain color gradations and appeared to belong to the seas areas, were resolved in very complex networks of lines. And the curious and unexpected effect was revealed of the "gemination" of the "canali", that certainly will have important consequences on current opinions about the planet's physical structure."* The splitting of the "canali" was confirmed by many other observers, and their interpretation lead support to the hypothesis that they could be artificial structures. The French astronomer and popular writer Camille Flammarion wrote: *"... if those "canali are real, they do not look natural, but it seems more reasonable that they represent ... the industrious work of the planet's inhabitants."*

The idea of an intelligent life beyond Earth conquered immediately a rich amateur astronomer in the United States, Percival Lowell. He was perhaps mislead by a mistake in the translation from italian to english of the term "canali": the transaltor used "canals", a word that indicates a man-made construction, instead of the more appropriate word "channels" indicating a natural configuration. Lowell built privately an observatory with a 45 cm refractor in Flagstaff, Arizona, in 1893 and later a 61 cm Clark refractor to study the gemination: he proposed that it was due to an artificial hydrographic network with locks used to irrigate the dry planet. There was intelligent life on Mars!

Schiaparelli continued his observations of Mars during other oppositions in 1884, 1886 and 1888, when he could use a new competitive telescope, a 49 cm Merz refractor. His last observations were in 1890, when he was confirmed in the idea that the "canali" were natural water flows that became visible in the occasion of big floods occurring at the melting of the polar caps. He was always very sceptical about the possibility they could be artificial. In 1893, when Lowell inaugurated his observatory, he wrote: *"The "canali" network was likely determined by the original geological sate of the planet, and slowly evolved in the centuries. We do not have to assume the work of intelligent beings: notwithstanding the almost geometrical appearance of the whole system, we are inclined to think that they are produced by the evolution of the planet, similar to the English or Mozambique Channels on Earth ... We can hope that the question can be solved by new data ... confident in what Galileo called the "courtesy of Nature", thanks to which some unexpected ray of light comes to clarify arguments that may appear inaccessible to our speculations."*

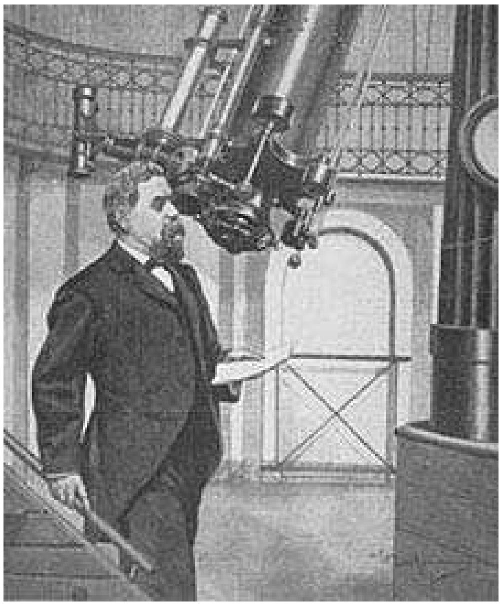

Fig. 4. Schiaparelli at the 49cm refractor

In 1900 the amateur astronomer Vincenzo Cerulli who had established a small observatory in Collurania near Teramo in Italy used a 40 cm Cooke refractor to study Mars and proposed that "canali" and gemination were the result of a psychological effect on visual perception: they were just illusory images created by very small details beyond the limit of sensitivity of the visual observation at the telescope.

The "courtesy of Nature" invoked by Schiaparelli brought the solution of the question in 1909, a year before his death, thanks to the observations of Eugène Antoniadi by means of the 83 cm refractor at the Observatory of Meudon, Paris. *"Nobody ever saw a real "canale" on Mars, Schiaparelli's "canali" do not exist in rectilinear form nor single nor double nor geometrically organized. However they have a correspondence with reality because the planet's surface show irregular stripes, more or less continuous and spotty, both rugged edges of dark regions and complex and isolated lakes. Mars shows everywhere these irregular and natural details, a characteristics similar to any other body of the solar system."* This interpretation is confirmed today by the close-by images obtained by the space probes and landers. No doubt: Mars is a rather inhospitable place, well different from the dreams of Flammarion and Lowell.

Mars was not the only planet that Schiaparelli investigated. After detailed observations of Venus and Mercury he determined their rotation axis and announced that their period of axial rotation was the same as their sidereal period (the time taken to orbit the Sun, relative to the stars). Thus they would always keep the same face to the Sun. It was not until the early 1960s that this view was disproved, and then only by the use of sophisticated radar techniques.

Schiaparelli became an important figure at the national level and was elected member of the Lincei Royal Academy, the Royal Academy of Sciences of Turin and the Royal Institute of Lombardy; he was one the important Italian scientist of his time, together with Cannizzaro, Celoria, Righi, Millosevich, Tacchini, Volterra. He obtained also important international awards, the Gold Medal of the Royal Astronomical Society in 1872 and the Bruce Medal in 1902. He was elected Senator of the Kingdom of Italy in 1889.

3. Schiaparelli and the history of astronomy

Schiaparelli retired as director of Brera Observatory in 1900 and, while continuing to follow studies of stellar astronomy and planetary physics, devoted himself to the discipline of the history of astronomy that he had already approached in his Berlin period. He believed that it was essential to know the historical evolution of his field of research and began a vast and important project of a complete survey of ancient astronomy. Unfortunately he could not complete it because of his failing health. However he published some excerpt; several unfinished chapters of his work were preserved in the archives of Brera Observatory and were collected in the book "Writings on the History of Classical Astronomy" published posthumous in 1925 by his son Attilio Schiaparelli and Luigi Gabba.

The book is characterised by a pleasant, attractive prose, never arid, even in the techical parts of the discussion. The first part of the book is devoted to the Babilonian astronomy, with a detailed description of the methods used to calculate the visibility of the planets Venus and Mars in VIII - VII centuries a. C. For these studies Schiaparelli had to read and interpret hundreds of Babilonian clay tablets reconstructed by the Jesuit fathers Strassmaier, Epping and Kugler. Then the progress of astronomy is followed through a synoptic vision of the developments and interactions of the great civilizations of Persia, Greece, India, up to the Arab astronomers. In this context Schiaparelli analyzes also the astronomical tradition of the Old Testament. In particular he discusses the astronomical passages of the Book of Job, where names of stars and constellations are reported. He read the original text in Hebrew language. This part of his work was published in a more extended book "The Astronomy of the Old Testament" in 1903 in Italian and in 1905 in German and English. There he dedicates much attention to calendars, as a fundamental element for cronology but also to understand the everyday rhythms of work and life.

The second part of the book surveys the Greek astronomy and includes a discussion of the measurements of the sizes and proportions of celestial bodies and the extension of the known universe that had already been published separately in 1867. Schiaparelli analyses the astronomical research of Pythagoras, Plato, Heraclides Ponticus, Ecphantus, Aristarchus of Samos, Seleucus, and establishes connections of Greek with Indian astronomy, namely with the astronomers Aryabhata and Prithûdaka. He was the first to realize that the concentric spheres of Eudoxus of Cnidus and Callippus, unlike those used by many astronomers of later times, were not to be taken as material objects, but only as part of an algorithm similar to the modern Fourier series.

4. Schiaparelli and his legacy

Schiaparelli passed away in Milan on the 4th of July of 1910, saluted by a new appearance of Halley's comet at perihelion. His name has been given to Asteroid 4062, to a crater on the Moon and to a crater on Mars.

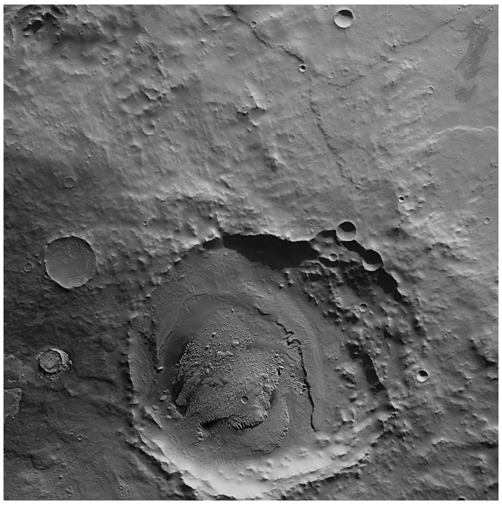

Fig. 5. Schiaparelli crater on Mars

He could have never imagined that just seventy years later Man would have sent probes and instruments on the planet Mars that he studied with enormous effort and difficulties through his lenses; and that hundred years later we plan to visit Mars. However he would be proud to see that the images collected by space probes repeat the signs of canyons and mountains that he had depicted in his drawings. A big reward for a man who portrayed himself modestly: *"little memory, no genius, much endurance and infinite curiosity to know everything."*

Acknowledgements. I am grateful to Claudio Casacci for providing historical material for this presentation.