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One century of Solar Physics in Italy 1850-1950

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Abstract. In this paper we briefly describe the story of Solar Physics in Italy during one century and we try to evaluate its international impact. At the beginning, in the serendipitous phase, we have e relevant contribution of italian solar physicist like Secchi and Tacchini. The choice of the Abetti father and son to build in Arcetri a Solar Tower, under the technical supervision of George Ellery Hale, could have given to italian solar physics the trust to compete in the international arena. However the lack of necessary technology, the war, and the choice to use the tower for patrol of the solar chromosphere kept italian solar physics from developing at the level of its competitors at the end of the first half of the XX century.

Key words. History of science– Solar Physics – Italy

1. Introduction

Science should have no borders. However the difficulties in communications, different political regimes and research policies gave rise to national sciences at least until the end of the second World War. We can therefore speak of an Italian Solar Physics which merges in the global science in the second half of the XX century. In this paper we briefly review its history from the first works of Secchi and Donati trying to evaluate how the work of the italian scientists has been evaluated abroad.

2. Solar science in Italy in the XIX century

At the beginning of the XIX century astronomers had very good tools (theoretical and observational) to speculate about solar apparent motion in the sky, solar distance and all the mechanical parameters involved in the orbital motion of the Earth, but were lacking of tools for the physical study of our nearest star. Knowledge was a privilege of few, and among those we may consider Antonio Cagnoli.

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2.1. The physics of the sunspots

Cagnoli[1], in his handbook of Astronomy titled *Notizie Astronomiche* (Cagnoli 1827) writes: *Pende ancora fra gli astronomi la soluzione del problema: cosa sieno le macchie del Sole; e forse penderà per non breve tempo avvenire........Non è quindi appieno inverisimile per quanto riguarda la congettura, che le macchie siano scorie o sostanze poco gravi fluttuanti nella materia ignea del Sole.*

The *Notizie astronomiche* were written for a cultivated reader (nobles or officers of the army), but we may consider these words as representative of the general ignorance about the facts of the Sun. The situations deeply changes in about fifty years thanks also to the work of Angelo Secchi[2] who reviews the results obtained in this field in a fortunate book edited first in French, in Paris, and than in Italian in Florence (Secchi 1884). This book was internationally appreciated and it may be considered the first textbook in solar physics. In this book we may find a lot of interesting details, as the description of the the structure of several spots and the discovery that sometime clouds, pink in color, were present on the spots. The obvious conclusion was that these clouds could be the same red prominences observed at the limb of the Sun during total solar eclipses. Interesting results were obtained in the year 1852 on March 19 by Angelo Secchi with a thermopile placed behind the projection plane of the Cuchoix telescope of the Osservatorio del Collegio Romano. Secchi was able to diaphragm the pinhole down to one arc minute, obtaining a ratio about two in *potere calorico* between the center and the limb (Secchi 1884). Secchi remarks that his measurements were the first of this type.

2.2. Solar Corona and the prominences

Another problem *on stage* in the middle of the XIX century was the nature of Solar corona and the location (Sun or Moon) of solar prominences. Also in this field italian scholars, with Donati[3] and and Secchi were well in the front of the research. During the solar eclipse 1842 Arago extensively described the Corona end prominences observed during the total solar eclipse, sim-

[1] Antonio Cagnoli, astronomer, meteorologist (1743-1816), as secretary of venetian ambassador in Paris was able to meet Lalande who introduced him to astronomy. He developed his astronomical interests using his own instrument first in Paris and than in his hometown, Verona where he built an observatory. In the year 1796 he was appointed president of the *Società Italiana delle Scienze*. The *Repubblica Cisalpina*, formed in northern Italy by Napoleone, transferred the Society in Milan and the instruments of Cagnoli were moved to the Brera Observatory. Cagnoli ended his scientific career as professor of *Matematica Sublime* at the military Academy in Modena.

[2] Angelo Secchi S.J. (1818-1878) born in Reggio Emilia, was educated by the Jesuits. In 1835 he is at the observatory of *Collegio Romano*, the Jesuit main house in Rome, as student.
In the year 1848 he is in Georgetown, close to Washington working with Curley director of that astronomical Observatory. Back to Rome he succeeded in building a new and original meteorological instruments which was appraised with the Gold Medal at the Universal Expo in 1867. Due to the poor mechanical stability of the astronomical instruments at the Observatory of the *Collegio Romano* Secchi, as he writes, decided to study the physics of the Sun, and few months before his death, writing about his studies, he recognizes to have given a contribution to the new science of Solar physics. He was too modest, his contribution was outstanding and his fame rapidly spread out the narrow borders of Italy (Righini 1978).

[3] Giovan Battista Donati (1826-1873) studied in Pisa and in 1852 is in Florence as assistant of Giovan Battista Amici, His major achievement is the first attempt of spectral classification of stars. In 1860 he is in Spain to observe a total solar eclipse and again in Sicily for the eclipse of 1870. In 1872 he was able to dedicate the new observatory build in Arcetri, on a small hill south of Florence. (Bonelli 1971)

ilar observations were reported also by Vassenius since 1733 but Arago's description had a worldwide resonance. The solar eclipse in Spain, in 1860, was an excellent occasion for the astronomers coming from all Europe to observe the black sun and among them we find Secchi and Donati. Donati confirms the correspondence, between sunspots and prominences (Donati 1866). Secchi brought in Spain the Chauchoix objective of the Collegio Romano and, very wisely, did not use any anlarging device for obtaining photographic pictures of the eclipsed Sun. The focal lenght was of about two meters just allowing a good resolution on the plate. A comparison of these pictures with those obtained by De la Rue at Rivabellosa on the Atlantic side of eclipse path, clearly showed the parallax effects on the Moon but the identity of the position of the prominences, confirming that they were solar in origin.

2.3. Space weather

The cyclic character of solar activity was well known when a large aurora was observed in 1872 in the night between February 4 and 5 in a large part of the northern hemisphere also at low latitudes. Donati was persuaded that the causes of the aurora were solar (Donati 1873) or at least *cosmic*. In the first printed contribution the recently inaugurated Arcetri Observatory he published the results of an inquiry on the local time of occurence of the maximum of the phenomenon as observed in diferent part of the world. He had the support of the italian ministry of foreign affairs which sent to the italian consular authorities around the world a questionnaire prepared by Donati. Answers arrived from Shanghai, Tiensin, Bombay, Taganrog, Damasco, Beirut,Saint Petersburg, Alessandria, Smirne, Tunisi, Glasgow, Cadiz, Melbourne, Santiago. From United States Donati received a detailed report from Joseph Henry, president of the Smithsonian in Washington. As a result of all these reports Donati was able to find that the maxima of the auroral phenomena propagated from east to west but they were observed at about the same local time. The conclusion of the paper was that a *a new meteorology* was needed that Donati defined as *cosmic meteorology* (we now would translate in *space weather*).

2.4. The solar spectroscope and the *Memorie degli spettroscopisti italiani*

It was october 20, 1868 when the news arrived in Europe that Janssen observed with the spectroscope the C line at the limb of the solar disk where the day before during a solar eclipse there was an outstanding prominence. This result opened new perspectives in prominence observations, each small refractor with just a simple spectroscope, mounted at the focal plane, could be used to observe prominences both for physical purposes and for just recording the geometrical parameters of the phenomenon. The two roman observatories: the *Collegio Romano* and the *Campidoglio*, were between the first institutions to be equipped with the spectroscope (Monaco 2000). Obviously a new observation device triggered a large amount of observational routine work not very different from that of the meteorologists and consequently the need of keeping a log. Therefore the italian community was forced to start a new scientific society and a new journal: the *Memorie degli spettroscopisti Italiani* which was mainly intended for the publication of the result of the spectroscopic measurements performed on the Sun, but not only. The first suggestion of founding the *society degli spettroscopisti italiani* was coming from Secchi as Tacchini writes in the *Memorie* (Tacchini 1872) *il Secchi mi comunicava l'idea di formare una società di Spettroscopisti Italiani, i quali lavorando di comune accordo e secondo un programma stabilito, avrebbero dato in poco tempo le richieste serie di regolari e continue osservazioni per la sicura ed accelerata soluzione* *di importanti problemi relativi alla fisica solare*. The international role of the italian solar spectroscopists was reflected by the structure of the *Memorie*. We find several papers of known foreign scholars and, sometimes, also translations of papers appeared in other journals. At the end of each volume of the *Memorie* it is possible to find drawings of the shape of the observed prominences and some remarkable engravings. The Memorie accepted also interesting discussions on several topics, as for instance, a project for the reform of the italian observatories, reports of solar eclipse expeditions and spectroscopic studies of wines for fraud detection.

2.5. *The international impact of Italian Solar Physics at the end of XIX century*

In the year 1885 A. M. Clerke published a fortunate history of Astronomy of the XIX century (Clerke 1885). The book, although written for non scientists, is very scrupulous in the citations and therefore it is valuable to assess a criterion to evaluate the impact of the italian Solar Physics. We find quoted Secchi, Tacchini, Riccò in connection with solar arguments, other italians are, obiously, Galileo, Riccioli, Donati (for the comet and for stellar spectra), Melloni for the lunar heat, Rosetti for the temperature of the Sun and Piazzi. The total quotation referring to solar arguments are about sixty therefore we may define an *impact factor*[4] of about 0.07 over the universe of solar physicist quoted by A.M.Clerke. We may consider this number a very good result if we keep in mind the complex political history of Italy in the XIX century. However during large part of the XIX century solar physics was in its serendipitous phase. In this phase all that is needed is fantasy, intuition, and deep interest in observations. All these qualities are well present in Secchi, Tacchini[5]. Riccò[6]. No need of team work, and no need of large instrumentations. The research at this stage is simple, not expensive and the intelligence and personal sacrifice of single scientist are enough to obtain universally acknowledged results. The situation drastically changes in the following fifty years.

3. Solar physics in Italy in the first part of the XX century

3.1. *Antonio and Giorgio Abetti*

Italian Solar physics is in debt with Antonio Abetti[7] of the intuition that the astronomy was changing. His younger son, Giorgio was willing to work in Astronomy and Antonio sent him several times overseas were new ideas were flourishing, especially due to the appassionate effort of George Ellery Hale, the *Maestro*, as Giorgio called him when he was in Mt. Wilson (Wright 1966). Giorgio met also Hale's

[4] Hereinafter, we will call *impact factor* the ratio of quoted italians over the universe quotation in the considered review or book.

[5] Tacchini born in Spilamberto (Modena) in 1838 was a skillful observer and a very active scientist. In 1878 he observed in India with the spectroscope the inner corona and discovered several lines in red end of the spectrum. Again Tacchini observed the coronal spectrum in 1883 in the Marquesas islands in the Souther Pacific and in many other solar eclipse expedition. He founded the *Memorie degli Spettroscopisti Italiani*. He died in in 1905.

[6] Born in Modena in 1844 he was director of the Catania Astrophysical Observatory, He organized several eclipse expeditions and following and with hale he tried to make photographs of the corona outside an eclipse from the ton of Etna using a spectroheliograph. He died in 1919

[7] Antonio Abetti 1846-1928 received a degree in engineering from the University of Padua. Than he was appointed astronomer at the observatory of that university and in 1894 becomes director of the Acetri Observatory in Firenze. Abetti's activity was essentially devoted to positional astronomy. In Arcetri he was able to carry out many observations on small planets, comets and fixed stars (Abetti 1970).

coworker and could work with the new instruments that Hale had built on top of the mountain; coming back to Florence, he felt that to give a new impulse to italian solar physics, a Solar Tower was needed and, as early as 1919, we find the first letters written by Antonio (director of the observatory until 1924) asking for money to start the building of the tower.

4. George Ellery Hale, Giorgio Abetti and the Arcetri Solar Tower

In Arcetri a large part of the correspondence between Abetti and Hale has been preserverd and catalogued thanks to the efforts of the library staff (Baglioni et al. 1999). We shall leave that the letters talk:

Hale to G. Abetti Nov. 1915 .... *I am much interested to hear of Professor Garbasso's*[8] *plans for astrophysical research in Arcetri, and shell be glad of any further information you can give on this subject......*

Hale to G. Abetti August 26, 1919 .... *It was a great satisfaction to learn that construction of a tower telescope has been decided upon, and I am looking forward with great interest to the first draft of the tower and location, which you promised to send in the near future....*

Hale to G. Abetti October 10, 1919 ....*I have cabled you to recommend that work be stopped on the well and foundations for the tower telescope, because I think a number of changes should be made in the design... .....In your drawing the second mirror is shown north of the coelostat, but it should be south......*

It is clear that Giorgio Abetti was completely dependent on Hale about the technical characteristics of the telescope, it is strange that he passed a drawing with a so big error i.e.: the secondary mirror north of the coelostat.

Hale to G. Abetti October 18, 1919 .....*This brings the question of the design of the coelostat and second mirror......I think the scheme indicated on the enclosed blueprint is worthy of your careful consideration.......One of the reasons I cabled you to advise that work be stopped was the fact that in your drawings the second mirror is shown north of the coelostat instead of south, where it should be placed, if you had put in the foundations of the tower, they would have been in the wrong position with reference to the well [I advise you not to put the foundations and build the house at foot of the tower until you have completely all the drawings of the coelostat and spectrograph (and spectroheliograph)*[9] *]*

Hale to G. Abetti October 20, 1919 *I now enclose the revised drawing, which I think is very satisfactory......* Hale sends to Abetti the blue prints of the Mt. Wilson 13 foot spectroeliograph on January 20, 1920, on February 20, 1920 Hale writes to Abetti the dimensions of the optical parts. The tower was completed about 1924 and Hale writes to Abetti on October 9, 1925 ....*I hope your spectroheliograph is now working well and am anxious to see the first results with it.* The tower does not work at its best, due to the bad quality of the gratings and to the periodic errors of the driving mechanism of the spectroheliograph. Hale, however, is favorably impressed by the very preliminary results obtained by Abetti on the large Evershed downdrafts he observed above the sunspots with the spectrograph.

The frontier of solar research was moving and the new problem was the measurements of magnetic fields. Abetti is very anxious to obtain some results in this field, but Hale in the letter dated November 23, 1926 writes ....*I doubt if you can do much work on the magnetic fields in sunspots, as your solar image is too small for any but the larger spots and the dispersion of a 13 foot soectrograph is too low. In fact, as I found with our 30 foot spectrograph, a much higher dispersion is really needed for*

8 Antonio Garbasso was professor of physics at the Regio Istituto di Studi Superiori, which will become in 1926 the Università degli Studi di Firenze

9 Handwritten by Hale in a typed letter.

this work, and this is why we built the large tower. Abetti was obviously not very happy of what his *Maestro* was writing to him and tries hard to obtain better results with the tower. Hale to Abetti October 11, 1927 *.....the spectroheliograph pictures you sent me seem to be very good, except of for the lack of good definition. I believe however, that they are as good as I shall be able to obtain here in my solar laboratory*[10]*, where the seeing is certainly not very promising.* This letter may be considered the closing end of the early history of the Arcetri Solar tower. A blue print of an old instrument, the first solar tower of Mt. Wilson, built in Italy under the supervision of Hale and in part with the money of the Hale foundation. We must say that Abetti had great difficulties to collect all the money needed to build the tower, and that he would not be able to build a larger one. Moreover he had not the key technology, i.e.: he was not able to build gratings and he had to accept the grating that were not good for Mt. Wilson Solar Tower. How difficult was for him to put the solar tower in operation comes out clearly reading the tower logbook. The tower however played a key role in the development of Solar Physics in Italy until it was used as a research instrument and not for routine observation.

5. Solar physics in thirties of the XX century in Italy

The extended and well documented review by G. Abetti (Abetti 1929) in the Handbuch der Phisik is very useful to understand the quality and the international impact of the italian solar physics at the beginning of the thirties of the XX century. The review by Abetti is comprehensive of every aspect of solar physics ad it has been universally acknowledged, in later reviews, as well documented and complete. The reference list of this review should therefore be considered, from the italian point of view, as unbiased by the language effect[11] and by the scarce popularity of scientific magazines in which italians were used to publish. Using this list the risk could be to overestimate the italian contribution but a punctual analysis of the papers shows the great equilibrium used by Abetti in its quotations. In Abetti's review we find about 13 % of citations referring to italian scientists (including Galileo, Secchi, and one work of Millosevich on history of Astronomy). Many of them refer to *old* classical solar topics as the height of solar chromosphere, the size and distribution of prominences, and some to his own work on the Evershed effect. We find some quotations also to results about the spectra of prominences obtained by Taffara (Taffara 1929) in the Solar eclipse expedition. As soon as the review proceed to describe the magnetic phenomena on the Sun we do not find any quotation of italian work. This is obvious, the Arcetri solar tower was not able to provide any result in this field, as it did in the case of the Evershed effect. At the end of Thirties Unsöld published a book (Unsöld 1938) which has been generally recognized as fundamental for a generation of astrophysicists working from the Fourties to the Fifties of XX century. We find quoted the review by Abetti in Handbuch der Physik, some other works by Abetti (Abetti 1932) and Calamai (Calamai 1934) on doppler shift of lines in prominences, a statistic on latitude drift of prominences during the solar cycle by Bocchino (Bocchino 1933), a paper by G. Righini (Righini 1935) on the center limb-variation of sodium D line, written on data obtained at the Arcetri solar Tower, and some old papers by Mascari on active regions and Riccò on prominences. We note

[10] In Pasadena.

[11] Language was a great barrier in the spreading of the scientific results obtained by italian researchers; they published in italian and mainly in the observatory series, which were exchanged by observatories, but were not so attractive for the reader as could be the Astrophysical Journal and the Zeitshrift für Astrophysik. Perhaps this provincial choice might be dictated by political constraints.

that in Unsöld's handbook no other italians were quoted and all those who Unsöld considered worth of quotation were solar physicists. If we want to evaluate a sort of impact factor of italian astrophysics from Unsöld point of view we do not go further than a scarce 1%.

6. Italian Solar physics at the end of the fifties of XX century

In the year 1952 Gerard P. Kuiper signed the introduction to the first volume of a series of four *intended to give a systematic and comprehensive account of our present knowledge concerning the sun and the other members of the solar system* (Kuiper 1953). The first volume deals with the Sun, and the different topics are reviewed by outstanding personalities in their field presumably well informed on contributions given by researchers all over the world. Leo Goldberg, in the introduction on the Sun, quotes and appraises the review by Abetti (Abetti 1929) and two interesting works by Cimino (Cimino 1944) (Cimino 1946) in connection with the *Secchi Rosa effect*, Strömgren, in his review, dealing about the Sun as a star does not find any italian work worth to be cited, while Minnaert, reviewing the solar atmosphere quotes several works as those on the Evershed Effect (Abetti et al. 1935) or on spectral line profiles (Barocas et al. 1951), (Righini 1933), (Righini 1946) and (Rosino 1939) or on a discussion on the sharpness of solar limb(Righini 1943). Van der Hulst, dealing with the Solar Corona, shows the importance of the italian activity in coronal studies, especially of the fortunate expedition in Siberia for observing the 1936 Solar Eclipse. We found quoted studies on minimum and maximum of the frequency of high latitude prominences in connection with ellipticity of coronal isophotes Abetti (1938) Biozzi (1939), while the observation of the coronal spectrum and its depression at λ 3850 Å is aknowledged, although non exclusively, to italians Doplicher (1946), Righini (1942). Also the observations by Fracastoro on the flash spectrum and on the variation of the height of the chromosphere deserve quotation (Fracastoro 1939), Fracastoro (1941). In the contribution on solar activity written by Kiepenheuer we find again quoted italian studies of the Evershed effect (Abetti 1932), about the spectra of prominence (Calamai 1934) and about the fluctuations of solar diameter (Cimino et al. 1946). In the other reviews, enclosed in the book, about line classification, radioastronomy, solar observing techniques, we do not find any quotations of italian work.

7. Conclusions

Italian Solar Physics well reflects the limits of the italian scientific community in the considered period. As soon as the results of the research depend only on the quality of the single person we find outstanding achievements as in the case of Donati, Secchi, Tacchini. We find also interesting results from the systematic observations of the Sun as the studies on the height of the chromosphere and on solar diameter. When the research needs large equipments and advanced technologies, Italy is not able any more to compete (as in the case of solar magnetic fields), and researchers, if they want to succeed, the should migrate as the italian nuclear physicists did at the end of the thirties.

The story of the Solar Tower in Arcetri tells that, notwithstanding the fact that the instrument was a copy of an aged prototype, it could have given results if used in a different way, i.e. as spectrograph, in that role the instrument was really outstanding ap to the beginning of the fifties. Unfortunately the tower was dedicated to the routine work of taking Ca II K and H_α spectroheliograms preventing *de facto* its use for reseach.

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