# P. ANGELO SECCHI, S. J. 1818 - 1878

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**At this commemorative Colloquium which is devoted to "Spectral Classification of the Future" it is fitting that we** should speak about the life and work of the man with whom all modern spectral classification started, Father Angelo Secchi who died here in Rome a hundred years ago in February 1878.

At the time of his death the name of Secchi was renowned throughout the scientific world, and his early death in his 60th year came as a great shock to the whole astronomical community - in the same way in which the untimely death of Father Treanor in February of this year is being deplored by astronomers all over the world.

Father Secchi was one of the great pioneers of astrophysics, or "physical astronomy" as he used to call it, whose work ranged over the widest possible field. He made fundamental contributions to solar physics as well as to stellar spectroscopy and he also worked with considerable success in geophysics and meterology.

For 28 years of his life Father Secchi was in charge of the Observatory of the Collegio Romano, the Roman College of the Society of Jesus, an observatory which he transformed into one of the world's best known and most respected scientific establishments.

Secchi was an indefatigable worker. In spite of many distracting duties which were forced on him by his official position Secchi managed to publish in the course of his life some seven hundred publications in many of the leading scientific periodicals of his time in France, Britain, Germany as well as Italy. These publications ranged from notes on recent

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observational discoveries to substantial treatises and books of which that on "The Sun" remained a classic for a long time.

Secchi was in the habit of treating one and the same topic in different ways in different periodicals, and this accounts to some extent for the exceptionally large volume of his publications. Even so, it has rightly been said that his work looks more like the output of a major scientific body than that of a single individual.

We come closer to the character of the man when we consider how Secchi managed to achieve all he did in circumstances which were by no means always favourable and whose sudden changes affected him at times severely.

We shall see how at the threshold of his scientific life Secchi was expelled from Rome in the upheavals of the revolution of 1848, and how later in 1870 he was put into a very difficult position after the collapse of Papal power and the occupation by the new Italian authorities of much of the Roman College.

However, Secchi was a man of singular determination who knew exactly what he wanted to achieve and who had a very clear understanding of what scientific problems he could expect to tackle successfully in the particular circumstances in which he found himself.

Working in Rome Secchi realized that the Roman climate offered him a substantial number of days and nights with exceptional transparency of sky and good image definition which would allow him to trace the very finest details on the solar surface, to observe faint diffuse objects such as the tails of comets or to collect the maximum amount of light into the slit of his spectroscope.

Secchi also was very much aware of the fact that the limited instrumental facilities at his disposal did not encourage major programs in positional astronomy which were normal activities at other observatories and which even as late as 1840 had been considered by no less a man than Bessel the only "proper" field for astronomical research.

It was fortunate for Secchi that personal predilection moved him in the same direction as instrumental limitations making him choose the new "unorthodox" "non-establishment" physical astronomy as field for his life's work.

One can probably advance one further point in explanation of Secchi's exceptional achievement as a scientist. This is that

he was the sole master of his scientific institution. Trusted and admired by his superiors in the Society of Jesus, he was not subject to the control by bureaucrats which all too often hampers scientific research at the present time.

Last but not least, Secchi was fortunate enough in having a very faithful patron who at all times was willing to assist his cause. That was Pope Pius IX who had come to the throne in 1846 only a few years before Secchi started his scientific work and who witnessed all Secchi's activities. Pope Pius died after the longest Pontificate in history only a few weeks before Father Secchi. Throughout his reign, which had been full of upheavals, the Pope retained a very keen interest in science and a warm friendship for Secchi.

I should now like to talk briefly about Secchi's early life before he became an astronomer. Angelo Secchi was born as the son of a carpenter on 29th June 1818 in Reggio in the province of Emilia some 200 miles north-west of Rome. At the time of his birth, which fell into the period of restoration after the downfall of Napoleon and his Italian Kingdom, Reggio had become part of the Duchy of Modena which was ruled by Arch-Duke Francis of Austria.

Secchi received his early education at the Jesuit College of his native town. At the age of 15 he left Reggio to enter the Society of Jesus at their Novitiate in Rome, and it was in Rome that he was to spend most of his life. Having completed the two years of the Novitiate he started in 1835 his humanistic and philosophical studies at the Collegio Romano, the Roman College of the Jesuits. It is said that here he became much attracted by the Classics and it is certainly true that he retained a strong interest in Classical Antiquity throughout his life. However, according to the Jesuit plan of study, philosophy also included science, and it became soon clear to his teachers that Secchi's particular interest and aptitude belonged in fact to science and in particular to physics and astronomy. These were taught by two remarkable men, Fathers Pianciani and de Vico, who had a strong influence on Secchi. De Vico was at that time the Director of the College's observatory where he came to be internationally known as a discoverer of comets.

His Jesuit superiors came soon to the conclusion that Secchi was ultimately destined for a life of study in physics and astronomy, and, believing that one gets to understand a subject best if one is forced to teach it, they sent him at the age of 23 for three years to their college at Loretto to teach Physics. When he returned to Rome Secchi was ready for his

theological studies which led in September 1847 to his ordination.

In the meantime the political world had become greatly disturbed in many parts of the Continent. As Karl Marx wrote at the time in London, the spectre of revolution was hanging over Europe. In February 1848 revolution actually broke out in Paris overthrowing Louis Philippe and then spreading to Berlin and Vienna. The revolt in Rome, the capital of the Papal States, had been from the very beginning of 1848 accompanied by an outburst of anticlericalism and by demands for the expulsion of the Jesuits. The situation became sufficiently threatening to force the Jesuit superiors to close all their houses in Rome and send the members of the Society into exile in countries like France, England and the United States. Among them was Father Secchi who went first, in March 1848, to the Jesuit house at Stonyhurst in England and half a year later to Georgetown in the U. S. A.

Secchi's exile did not last long, however, and his time in Georgetown was in fact far from wasted in that he met there the distinguished American hydrographer, Captain Maury, whose **work was to have a strong influence on Secchi's later studies in geophysics and meteorology.**

Back in Rome the Prime Minister of the Papal States, Count Rossi, had been assassinated, the Pope had left Rome for Gaeta, and the eternal city had been proclaimed a republic under Guiseppe Mazzini. It was a republic which however, was forced to capitulate when French troops occupied Rome in 1849 following an appeal by the Pope to the Catholic powers to restore him to his capital.

Among the Jesuits who were now ready to return from exile was Father Secchi who arrived back in Rome at the end of the year to take over the direction of the observatory and the Chair of Astronomy at the Roman College in succession to Father de Vico who had died in exile in London. Secchi was to remain in that position until his own death 28 years later.

At the time of Secchi's appointment the observatory was situated at the top of a high tower in the eastern part of the Roman College. It was both poorly placed and very inadequately equipped, and Secchi's main task in his first two years as Director was to improve the observatory's instruments and find a more suitable location for his telescopes.

Secchi wanted to work in physical astronomy which meant to him, before he got involved in stellar spectroscopy in the 1860's, the visual observation of the surface features of the

bodies of the solar system, the planets, comets and particularly the Sun, and also, somewhat surprisingly, the measurement of double stars and star clusters. In fact, he was so attracted by the possibility of working on double stars in conditions of good seeing that he chose as main telescope for his new observatory a visual refractor, identical in size to the then famous $9\frac{1}{2}$ inch refractor which Fraunhofer in Munich had constructed thirty years earlier for Dorpat University in Estonia where it had been used by F.G.W. Struve for his monumental catalogue of double stars of 1837. Secchi commissioned the firm Merz in Munich to build his new telescope and he was immensely pleased when its optical performance turned out to be not inferior to Fraunhofer's earlier telescope.

As location for his new observatory Secchi chose, following an earlier suggestion, the roof of the beautiful Jesuit Church of San Ignacio which had been built in the 17th century into the northern side of the Roman College. This church was to be originally crowned by a large dome, second in size only to the dome of St. Peter's. Because of the untimely death of the architect the dome had remained unbuilt, however, which enabled Secchi to make use of the strong pillars which originally were to support the dome, to form a base for the erection of his telescopes in conditions of perfect stability.

The telescopes which he mounted on this church roof were his new $9\frac{1}{2}$-inch Merz refractor, an earlier remounted 6 inch refractor by Cauchoix to be used for solar observations and a transit circle by Ertel which marked the Rome meridian. All Secchi's telescopes were more than modest by present-day standards, and it is all the more remarkable, of course, what wealth of astronomical information they yielded in Secchi's hands.

Like other astronomical observatories, the observatory of the Roman College had from its beginnings in 1811 a meteorological station attached to it. Secchi continued its long series of meteorological records with improved instruments and in particular with his much treasured "meteorograph" which he had designed himself and which recorded automatically variations in atmospheric pressure, temperature, relative humidity and wind velocity. His strong interest in geophysics as well as meteorology led Secchi to set up in the rooms of the old Tower Observatory a complete geomagnetic station, the first of its kind in Italy.

On the roof of his new observatory he also mounted a time-ball which was dropped at midday to be followed by a time gun which was fired from the Castel San Angelo. This new time

service of Secchi's heralded the acceptance in Rome of mean solar time as standard civil time which the Pope was anxious to see introduced in replacement of the curious former system in which days and nights had been divided into 12 hours each throughout the year so **that hours in winter were much shorter than in summer. Secchi tells us, however, that the new reckoning of time was by no means received with general enthusiasm by the Romans.**

His Merz refractor had hardly arrived in Rome in 1852 when Secchi started using it for a revision of Struve's great catalogue of double stars, the "Mensurae Micrometricae." In seven years of systematic work he measured more than 1300 binaries, and it speaks for his remarkable skill as a telescopic observer and for the seeing qualities of the Roman sky that Secchi was able to remeasure not only the majority of binaries in Struve's catalogue, but many more difficult ones which Struve had only been able to resolve using his large 16-inch refractor at Pulkowa. Secchi retained a strong interest in the observation of binaries for most of his life, but in the 1860's stellar spectroscopy began to take an ever greater share of his time.

Secchi's remarkable skill as a visual observer - and practically all his work was based on visual observation - showed itself also in his investigations of the planets, particularly those of Mars. He spent much time tracing the fine structure of the rings of Saturn and of the surface at Ganymede the third satellite of Jupiter. In his observations of the planet Mars he was the first to notice the existence of peculiar straight-line structures which he called "canali", channels. This was long before the days when Schiaparelli discovered a whole network of such structures which Lowell later assumed to be actual canals.

The 19th century was one in which several bright comets with long tails made their appearance. The comet discovered by Donati in Florence in 1858 developed a tail which spanned an arc of 60 degrees across the sky corresponding to an actual length of some 70 million kilometres or half the distance between Sun and Earth.

Like his predecessor Father de Vico, Secchi considered it to be his duty to do all he could in the observation of comets. He studied the changes in the structure of more than half a dozen comets in considerable detail. He was the first to spot the two nuclei of the double comet Biela on its return in 1852, its last appearance before its dissolution into a swarm of meteorites. Secchi describes how he observed an exceptionally

brilliant display of meteors which fell from the sky like a great rain of fire, "una vera pioggia di fuoco," on 27th November 1872 when the former comet Biela was supposed to come particularly close to the Earth.

Secchi extended his observations of meteor showers like the Perseids and Leonids to determinations of their heights above the ground by simultaneous observations from several positions such as the Roman College and a station at Civitavecchia some 70 kilometres north-west of Rome.

The Sun was Secchi's favorite object of study for many years, and he became soon recognized as a leading authority in the field of solar physics. His great book on the Sun which appeared first in 1870 and in a second two-volume edition in 1875, contains many splendid drawings of his of the fine structure of the photosphere, the solar granulation, and of the details in the structure and its variation of umbra and penumbra of sunspots.

When Secchi started his solar work in the 1850's solar prominences were well known to exist following their observation at the total eclipses of 1842 and 1851. Their nature, however, was very much a matter of dispute. Some astronomers believed that prominences were optical illusions, mirages produced by the terrestrial atmosphere. Others thought that they were part of an atmosphere which surrounds the moon.

One obvious way of settling this question was to make photographic observations of the eclipsed Sun by more than one observer. Though photography was still in its infancy at the time and though his skill was in visual observation, Secchi decided to embark on the experiment at the total eclipse of 1860. His preparations for the work included a series of experimental photographs of the different phases of the Moon.

The track of the 1860 eclipse crossed Spain, and it was there that Secchi took his 6-inch Cauchoix refractor to which he had attached a specially constructed photographic camera. A well-known English observer, Warren de la Rue, arranged to photograph the same eclipse from a station 250 miles to the north-west of Secchi's.

Each of the two observers managed to obtain several good photographs with images of prominences and corona which agreed with each other in every detail. This was the first demonstration of the fact that prominences and corona are not spurious, but real phenomena and that they have a physical connection not with the Moon, but with the Sun.

If eclipse photography started in 1860, eclipse spectroscopy started at the eclipse of 1868. Secchi was unable to observe this eclipse himself much to his regret, but he followed eagerly the observations which Janssen of Paris made then, and he applied immediately to his own solar work Janssen's principal discovery, that it is possible to observe both chromosphere and prominences outside eclipses using a spectroscope.

From 1868 onwards Secchi extended his daily systematic observations of the Sun to include all transient solar phenomena, sunspots, faculae and dark filaments on the solar disc, and chromosphere and prominences at the solar limb. He made most careful observations of the motions of prominences and the sudden accelerations in the motions of eruptive prominences. It is worth remembering that Secchi was the very first to notice the existence of the little jets in the solar chromosphere which we now call spicules.

It would not be an exaggeration to say that the superb quality of Secchi's visual observations of these transient solar phenomena which he carried on for seven years, was not surpassed until the advent of Bernard Lyot's H$\alpha$ filter photography in the 1930's.

Secchi had a keen interest not only in solar activity itself, but also in the question of its possible relationship with terrestrial phenomena. Having added to his astronomical observatory a well-equipped geomagnetic station he was in a position by the 1870's to compare his own substantial observations of sunspot activity with his own records of geomagnetic disturbances. In this way he was well placed to test and, of course, to confirm Sir Edward Sabine's discovery of 1852 of the coincidence between the period of geomagnetic activity and the 10-11 year sunspot cycle which had been discovered by Schwabe a year earlier.

There are many other aspects to Secchi's work in the field of solar physics such as his skill in the design and use of instruments, and it can well be said that his place in history of astronomy would be assured if he had done nothing else but solar work.

He is, however, undoubtedly remembered chiefly for his work in stellar spectroscopy and stellar astronomy in general. His last book which was published only a year before his death, is entirely devoted to stellar astronomy. Though not as much a classic as his earlier book on the Sun, his book on stars contains a very readable summary of the sidereal astronomy of

his time and of his own contributions to the field. Amongst these was his work in visual stellar photometry, both relative and absolute, his photometric comparisions between stars of different magnitudes and of stars with artificial light sources placed at the top of Monte Cavo ten miles from his observatory.

However, Secchi's most important contribution to stellar astronomy is, of course, his work on stellar spectra which led to the first spectroscopic survey of the heavens.

The spectroscopy of the Sun and certain stars had started with Fraunhofer in Munich who discovered in 1814 the dark lines in the solar spectrum which are named after him. In 1823 he succeeded using very modest equipment in seeing similar lines in the spectra of Sirius, Castor, Capella and a few other bright stars. He discussed differences between these spectra in a famous paper in the Edinburgh Philosophical Journal of that year. After Fraunhofer's early death in 1826 Lamont, the Scottish-born Director of the Munich Observatory, tried to extend Fraunhofer's work to other stars without any notable success.

Stellar spectroscopy remained dormant for the next thirty years, and a first attempt by Secchi to enter the field in 1855 was soon abandoned by him in favor of other work. He only returned to spectroscopy in 1862 stimulated by some pioneering observations of Donati's in Florence made with some inferior equipment. Secchi was more strongly influenced by improvements in the light-gathering power and general performance of spectroscopes which had been made in the meantime. Last not least, Secchi was caught up in the wave of enthusiasm for spectroscopy which followed Bunsen and Kirchhoff's announcement in 1859 and 1860 of the solution of the mystery of the Fraunhofer lines and their interpretation in terms of radiation theory spectrum analysis.

Secchi's great contemporary and co-worker in the field, William Huggins of London, hailed Kirchhoff's work which as he put it "had given a key into his hands which would unlock a door which had been regarded as forever closed to man."

In the 1860's then Secchi and Huggins became the leading figures in stellar spectroscopy. Unlike Huggins who concentrated on the detailed examination of the spectra of certain selected stars, Secchi set out to survey thousands of stars and group their spectra of some 4000 stars using for most of his work a simple spectroscope with a direct-vision Amici prism

and two cylindrical lenses which he attached to his 9½ inch Merz refractor. He planned at one stage to survey the whole sky, northern and southern hemisphere and to take his telescope to India for this purpose, but he found the project to be beyond his reach.

Secchi's first classification of stellar spectra of 1863 was based on observations of only 35 bright stars which he separated simply into two types, white stars like Sirius and colored stars like Betelgeuse. Three years later he introduced a third class, that of slightly colored stars with spectra similar to that of Arcturus, and in the same year he published his first catalogue of spectral types of some 200 stars. In 1867 appeared his famous catalogue of spectral types for some 300 stars which were separated according to their colors and line spectra into three different types. Finally, in 1868 he announced the existence of altogether four different types of spectra which are the so-called "Secchi types" of later years. His first type was represented by spectra of such stars as Sirius or Vega with strong absorption lines of hydrogen. This first class - corresponding to our A or early F-types - he found to be very numerous embracing "one half of the visible stars of the heavens." "Almost the other half of the stars" he said, "are yellow stars of the second type with spectra such as that of the Sun or Capella"' in other words more or less our G-types.

Secchi's third and fourth spectral classes, comparatively few in number, comprised two types of red stars. The third class included stars such as Antares or Betelgeuse whose spectra show, as Secchi put it, "a row of not less than eight luminous bands alternating with darker ones"; they correspond largely to our M-types. Secchi's fourth type comprised only a few stars, all fainter than the sixth magnitude whose spectra he found to consist of three luminous bands in the blue, green and red, separated by dark intervals. His bands are in fact the Swan-bands of carbon, and stars of his fourth class correspond to our R- and N-types.

Secchi was well aware of the existence of stars whose spectra indicated transitional stages between his first and second, and his second and third types. He knew also that there were stars whose spectra did not fit exactly into any of his types such as some of the bright stars in Orion which he listed as of type I O and which we now call B-stars.

At the start Secchi regarded his system of spectral classification as more or less empirical and arbitrary - just

as E. C. Pickering did later when he introduced his Harvard classification. In the course of time, however, Secchi already was led to the opinion that the spectral system might well represent actual variations between the different types of stars of physical conditions and in particular of temperature.

Secchi soon extended his observations of stellar spectra to the spectra of nebulae. This was a field in which William Huggins had discovered in 1864 the gaseous nature of at least some of the nebulosities, contrary to the then prevailing view that all nebulae were in fact distant unresolved clusters or systems of stars. Secchi fully confirmed Huggins' findings through his observation of the spectra of the Orion Nebula and other nebulosities which were located too far south to be visible to Huggins.

In the course of his observations of nebulosities Secchi had occasion to examine the detailed structure of the Milky Way, and it is interesting to see him contradict the view which was then generally held, that the dark areas in the Milky Way are holes through which we look out through our stellar system into the distant regions of the Universe. He suggests instead that they are - as, of course we now know - dark clouds of diffuse matter which obscure the light of the more distant stars.

All of Secchi's spectroscopic observations were made visually. They indicate a remarkable acuity of vision on his part. His method of visual observation broke down, however, very naturally when he attempted to measure the radial velocities of stars, something which had to wait for Vogel's and Huggins' photographic observations.

It is clear that Secchi was a prodigious worker who achieved results of great importance using very modest means. In this he was very much in the tradition of Argelander and the Bonn astronomers who in the 1850's created those most fundamental catalogues and charts of the Bonn Durchmusterung on the basis of countless observations with a tiny 3-inch telescope.

This is what George Ellery Hale said about Secchi seventy five years ago: "Few men have contributed more than Secchi to the present wide-spread interest in astrophysical research. His investigations are notable for the diversity of their objects, the ingenuity of the instrumental methods devised, and the tireless perseverance of the observer. In these respects they will stand as an inspiration to future investigators, and as a shining example to those who are called upon to obtain important results

with modest instrumental means. For Secchi's numerous contributions to science clearly show that the great telescopes of modern times, while indispensable for many investigations, are by no means to be regarded as essential to the successful pursuit of astrophysical research."

The great diversity of Secchi's research in solar and stellar astronomy, in geophysics and in meterology did not exhaust the range of his activities. Being the Pope's astronomer he was very much the Pope's scientific adviser, and the Pope of his days was not only the Head of the Church, but also the supreme ruler of the Papal States. This meant that Fr. Secchi was frequently consulted on semi-scientific problems which might affect the well being of the Pope's subjects in his territories. Secchi had to advise - to give an example - on the construction and proper equipment of lighthouses along the coast at harbors like Anzio, Civitavecchia or Ancona. He was specially asked by the Pope to investigate the reliability and purity of the water supply in country areas which implied long journey's of inspection of wells, hydraulic machinery and water pipes.

Closer to astronomy was a piece of geodetic work which he was asked to undertake, namely the remeasurement of the length of a baseline which had first been measured a century before by Father Boscowich for a triangulation of the Papal States. This baseline, about 12 kilometres long, stretched along the Via Appia between the well-known monument of Cecilia Metella and Frattochie. The Via Appia itself had only been excavated in the early 1850's from under mountains of rubble, and his geodetic work on the ancient road gave very special pleasure to the classicist in Secchi who took a similar delight in his discovery of ancient Roman waterworks during his journeys of inspection.

At a period when popularization was looked at with disdain by many scientists. Secchi considered it to be his duty to convey some of his own enthusiasm for his work to wider audiences through semi-popular writings and public lectures. He delighted in the latter, and we hear of the great success of a memorable lecture on the Sun which he delivered to an audience of more than 300 Cardinals, Bishops and Theologians who were assembled in Rome for the first Vatican Council in 1870.

Secchi was then at the height of his fame, recognized not only in his native Italy, but throughout the scientific world as one of the great pioneers in the new field of physical astronomy. As such he had been elected a member of all the principal Italian Academies such as the Academia Nazionale dei XL, and a foreign, honorary or corresponding member of all the

major ones on the Continent, in Britain, the United States and South America. He was president for life of the Academia Pontificia dei Nuovi Lincei, the predecessor of our present Pontifical Academy of Sciences.

Then a major change occurred in Father Secchi's world. Following the defeat of the French in the Franco-Prussian war of 1870 and the subsequent withdrawal of the French troops from Rome, the Italian nationalist troops under King Victor Emmanuel of Piedmont invaded the Papal States and occupied Rome itself on 20th September 1870.

What had been the Pope's city became the capital of the United Italy, thus ending the temporal power of the Papacy. Pope Pius IX, however, refused to recognize the new Italian State. For the next 8 years until the end of his life he remained a voluntary prisoner in the Vatican cautioning Catholics against taking any part in the political life of the new Italy.

As has happened in other political upheavals, life became extremely difficult for all those in Rome who out of loyalty to the Pope refused to join the party of the new administration.

Secchi's international reputation saved him from many of the major troubles which befell in particular members of the Society of Jesus. In fact, for a while considerable efforts were made to win his allegiance to the new regime through offers of positions of great honor and influence such as the Directorship of all Italian observatories. When he refused all these, however, he and his observatory were subjected to vexations which caused Secchi very considerable distress.

Father Secchi's loyalty to the Pope never faltered in these circumstances. As a loyal son of the Church and an exemplary priest he was inspired by deep reverence for the Pope, but he was also strongly moved by feelings of gratitude to his benefactor who had encouraged and supported all his work from its very beginnings. It was with such feelings that the dedicated to the Pope on his 50th episcopal jubilee one of his last major publications in which he surveys the progress of astronomical research in Rome under the pontificate of Pius IX.

The Pope's death at the age of 85 came as a great shock to Father Secchi who had been ill himself for some time. He was to follow his patron less than three weeks later, dying on 26 February 1878.

Thus ended the life of a remarkable man, a scientist and scholar of the first magnitude, and a man of great character whose life and work will indeed remain an inspiration for many years to come. No more fitting tribute could be paid to his memory than this assembly in his own city of Rome of so many distinguished astronomical spectroscopists from all over the world.

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