



Margherita Hack: a life for science

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Abstract. Stellar spectroscopy is the primary keyword to define the studies of Margherita Hack, but her scientific interests and research activities covered a broad range of astronomical topics in a variety of spectral regions, from the far UV to the IR and the radio, and included topics as different as Cepheids, stellar classification, the solar chromosphere, late type stars, the chemically peculiar Ap stars, mass loss in early type stars, the problem of Lithium, the galactic chemical evolution, the abundance of helium, stellar rotation, UV astronomy, and binary star evolution. Margherita Hack organized four international scientific meetings in Trieste (Colloquia on Late Type Stars, on Supergiants Stars, on Mass Loss from Stars and on High Resolution Spectrometry) and was very active in promoting the development of, and participation in new scientific projects based on space UV observations (Copernicus, TD1-S59, IUE). She encouraged fruitful collaborations with international scientific institutions and with researchers from the so called “developing” countries, and played an important role in the growth of the Astrophysics Section of ISAS-SISSA in Trieste. Her prolific activities as editor and writer resulted in the publication of dozens of scientific and popular books, including two volumes on stellar spectroscopy and the monumental NASA-CNRS Monograph on CVS and Related Stars.

Key words. Biographies – Stars: variables: Cepheids – Stars: spectroscopy – Ultraviolet: general – History of Astronomy.

1. Introduction

In the following I will give a necessarily brief overview of the most important aspects of the tireless scientific activity of Margherita Hack, which spanned more than 60 years.

2. A scientist's life: the early years

Margherita Hack graduated in Physics at the University of Florence in January 1945 with a thesis on the Cepheid variable FF Aql. Her study was based on observations she made in 1944 with a prismatic reflector with 30 cm mir-

ror at the Astronomical Observatory of Arcetri near Florence. It was wartime, and sometimes the observations were interrupted because of bombing raids. It was during the preparation of her thesis under the guidance of Prof. Abetti and Dr. Fracastoro that Margherita Hack familiarised herself with the basic techniques of photometry and spectroscopy. Her thesis was published in 1946 (Hack, 1946).

To illustrate the strong personality of Margherita Hack, even as a young student, it is worth noting that she initially enrolled at the University of Florence as a student of literature, but almost immediately after attend-

ing the very first class she decided to switch to physics. In 1944 she was at the final stage of her studies and was seeking a subject for her master dissertation. She was offered a classical subject on electrostatics which she found boring and rejected. This convinced her to look for another topic and she approached the Arcetri Observatory for an astronomical topic that appealed to her.

She encountered similar situations on several other occasions, but she always managed to make the decision that was ultimately more fruitful. In other words, when she came to a fork in the road, she always took the right fork.

After the thesis Margherita Hack continued her work on the Cepheid T Vul (Hack, 1948) as a volunteer assistant with brief short term grants. From spectrophotometric observations made with the prismatic reflector at Arcetri, the light curves for nine wave-lengths, the gradient temperature, and the spectrum variations were determined.

In May 1950, Margherita Hack was appointed staff member as “assistant” at the Chair of Astronomy at the Observatory of Arcetri, a position left by G. Fracastoro after his promotion to “full astronomer”. During these years Margherita Hack was interested in ζ Tau (Hack, 1951), a member of the class of Be-B-shell stars which are characterized by broad H emission lines and narrow absorption lines of once-ionized elements of the iron group and by cyclic transitions between the two states of emission (mostly H), and sharp absorption lines.

At the end of 1952, Margherita Hack received a grant for a six-month stay at the IAP-Institut d’Astrophysique de Paris to work with D. Barbier and D. Chalonge on the bi-dimensional classification of stellar spectra, i.e. on the quantitative spectroscopic criteria for determining the star temperature and luminosity from early A to late O stars. After a few weeks of boring and repetitive studies, Margherita Hack decided to use an alternative bi-dimensional classification technique based on the equivalent width of H_{δ} and the intensity of the Balmer jump. This new method, initially considered by Chalonge with some doubts, was finally fully accepted and in 1953

he proposed it for publication in the prestigious “Annales d’ Astrophysique” (Hack, 1953a).

In addition to this study, her stay at the IAP was extremely useful because of the several contacts she made with renowned colleagues during the Congress on Stellar Classification in Paris: E. Schatzman, J.C. Pecker, W.W. Morgan, and B. Kukarkin, the Russian co-author of the famous catalogue of variable stars (Kukarkin, 1995).

Back in Arcetri Margherita Hack continued the studies on Cepheids and Be stars and published a quantitative analysis of the atmosphere of the supergiant P Cygni type 55 Cyg using spectrograms taken at the Cassegrain focus of the reflector of the Asiago Observatory (Hack, 1953b), see also Umbriaco et al. (these proceedings). In the same year Margherita Hack published the results of a campaign of observations of the height of prominences in the solar chromosphere (Hack, 1953c).

In 1954, Margherita Hack published an important study on the quantitative analysis of stellar atmospheres by comparing the results obtained by her and by other authors who employed the Unsöld method to determine the relative He/H abundance in a sample of about 30 B6-O5 stars (Hack, 1954). In March, she qualified for university teaching (“libero docente” in Italian), the preliminary step to become full professor at the university.

In the same year, after the arrival in Arcetri of a new director who was interested in solar physics only, Margherita Hack decided to move to another observatory. She chose the observatory of Brera Merate, motivated by the presence of a 1m telescope equipped with a grating spectrograph which was ideal for stellar spectroscopy, her field of study. Margherita Hack arrived at Merate in July 1954, where she was hired as astronomer, and started a new line of research in addition to the earlier one on Cepheids, the one on the peculiar chemical composition of early-type stars classified as Ap and Am stars (Hack 1955, 1956a). Ap stars show unusually strong lines of Y, Si, Sr, Eu, as well as other rare earths, accompanied by strong magnetic fields of up to 10.000 Gauss. Am stars are underabundant in Ca and Sc and

have lower rotational velocities than normal stars.

As Margherita Hack later recalled (Hack 1998), she wished to have her results soon published in the “*Memorie della Società Astronomica Italiana*” but the director of that time put several obstacles in the way to publication and kept the manuscript in the drawer for some time. He finally decided to publish it in the “*Atti della Società Scientifica Lombarda*”, a journal of limited scientific importance.

At the end of 1954, Margherita Hack obtained a CNR grant for spending several months at the Utrecht Observatory, known for its school of solar astrophysics and stellar atmospheres. She had to fight again with the director of Brera-Merata who did not want to let her go, but who finally reluctantly agreed. In Utrecht Margherita Hack met M.G.J. Minnaert, J. Houtgast and C. De Jager and worked on stellar atmosphere models.

The publication of the textbook “*Corso di Fisica Stellare*” (Hack 1955), a result of her studies to be qualified for university teaching also dates from this period. For the astronomical community this book represented a new reference for the study of stellar atmospheres

2.1. Berkeley and O. Struve

In August 1955, Margherita Hack attended IAU’s IX Symposium in Dublin. She had the unique opportunity to meet Otto Struve, a famous astronomer (“the world’s foremost stellar spectroscopist” Kraft 2009) who was president of the IAU 1952 to 1955. As Margherita Hack later recalled (Hack 1998), it was her husband Aldo De Rosa who persuaded her to contact him, since she felt intimidated by his great fame. This represented a fundamental turning point in her career.

Struve accepted Margherita Hack’s request for a residency at the Astrophysics Department of the University of California in Berkeley. Margherita Hack received a Fullbright grant for the trip and a “Smith-Mundt” grant for her stay. In December 1955 she moved to Berkeley and began a long term collaboration and friendship with O. Struve and his collabo-

rators S.S. Huang, J. Sahade, G. Wallerstein, J. Greenstein, etc. In particular, she had exciting discussions with him about the interpretation of the spectra of some stars which, she said, were like old family friends to him.

First studies of interacting binaries: the high velocity spectroscopic binary BD+74°493 (Greenstein et al. 1957) and the exceptional system ϵ Aurigae (Hack 1957, 1959).

In 1959-1960 Margherita Hack was invited again to Berkeley for a full year as “visiting professor”. This gave her the opportunity to discuss with Struve all sorts of problems stellar spectroscopy could present. This became the subject of a project proposed by Struve and Margherita Hack for a series of monographs on stellar spectroscopy which they planned to write together.

2.1.1. The outstanding life of Otto Struve

Otto was the younger of six astronomers in the Struve family; it was his ancestor, another Otto Struve, who in 1838 measured the first star distances through the effect of parallax as the Earth orbits the Sun (Perryman, 2022). As mentioned by Hack (1998), the young Otto graduated from the University of Kharkov (Russian) or Kharkiv (Ukrainian) after the First World War. After the Russian Revolution, he fled to Constantinople, where he endured many hardships, having to work in very humble positions, always on the verge of starvation. Finally, in 1921, he received an invitation from Professor Frost, director of the Yerkes Observatory, to join his staff. He embarked as a stowaway on a merchant ship to the United States. Eleven years later, Struve became director of Yerkes. In 1950, he was appointed professor of Astronomy at the University of California at Berkeley. O. Struve was director of Yerkes and McDonald Observatories, professor of astronomy at Berkeley, president of the IAU from 1952 to 1955, director of the National Radio Observatory at Green Bank, and professor at the Institute for Advanced Studies at Princeton.

2.2. From mid fifties to the early sixties

In addition to the collaboration with Berkeley, Margherita Hack continued her studies in Merate on the luminosity classification criteria (the classification of HD188209 was changed to O9V instead of O9Ia after the result of a model atmosphere that gave $\log-g=3.7$ (Hack 1956b)), on the supergiant ν Cep (Hack 1956c), on the Be star ζ Tau (Hack 1958a) and on several Ap stars (Hack 1958b).

In 1959 the first edition of “Le nebulose e gli universi-isole” (Abetti & Hack 1959) was published with Giorgio Abetti, who was Director of the Arcetri Florence Observatory from 1922 to 1952. It is worth mentioning that he succeeded his father Antonio Abetti, who was Director from 1894 to 1921.

Around 1960, the recently developed interest of Margherita Hack in radioastronomy resulted in a series of lectures held at the University of Bologna and in a stay in Groningen for collaborations with A. Blaauw. This led to a study on “Large scale structure in the region around h and chi Persei”, Blaauw et al.(1962). The book “La radioastronomia alla scoperta di un nuovo aspetto dell’ Universo” is published (Hack 1960).

In 1961 Margherita Hack was invited to Ankara as a Lecturer of the Summer Course in Astrophysics, held in collaboration with Lynden-Bell. In 1962 she was in Princeton and Green Bank to continue the collaboration with O. Struve on the Monographs on Stellar Astrophysics. Regrettably, the health conditions of O. Struve appeared unfavourable.

Spectrographic observations of the eclipsing binaries 31 and 32 Cyg during the last eclipses revealed the presence of a strong chromospheric K line. (Hack 1962).

1964: Publication of “Esplorazioni Radioastronomiche” (Hack 1964).

1964: The English and updated version of “Le nebulose e gli Universi Isole” was published as “Nebulae and Galaxies” (Abetti & Hack 1964).

3. Director of the Astronomical Observatory of Trieste

In December 1964, Margherita Hack was appointed professor to the Chair of Astronomy at the University of Trieste and at the same time she became Director of the Astronomical Observatory of Trieste. This was not without the strong opposition of the former director, but the support of the physicists of the Institute of Theoretical Physics, in particular Paolo Budinich (co-founder of the International Center for Theoretical Physics (ICTP) with A. Salam), was decisive in her favor.

Before her arrival, research at OATS was carried out by a very limited number of staff on classical subjects such as positional astronomy and photometry. Solar radioastronomy was still in its infancy. In the course of a few years, Margherita Hack strongly boosted the scientific research and transformed the Observatory into a modern research centre, with substantial staff increase (from less than 10 people to about 40).

3.1. International Colloquia and Monographs

In the first years as Director, Margherita Hack organized four international scientific Colloquia on astrophysical topics in Trieste.

The first Colloquium took place in 1966 on late-type stars (Hack 1967a). Pol Swings, President of the IAU, encouraged Margherita Hack in organizing the Conference. The Colloquium was held at the International Center of Theoretical Physics in Trieste, thanks to the hospitality of the Director and future Nobel Laureate Prof. Abdus Salam. Distinguished contributors are: C.E. Moore, K.O. Wright, J. Smak, Y. Yamashita, B.E.J. Pagel, G. Carel, R. Kippenhahn, O. Gingerich, J. Linsky .

In 1967, after Professor Pol Swings suggested Margherita Hack to collect scientific papers from astronomers who worked with O. Struve, the book “Modern Astrophysics, a Memorial to Otto Struve” was published by Margherita Hack (Hack 1967b), with no-

table contributions by E.R. Mustel, W.W. Morgan, E. Boehm-Vitense, G. Wallerstein, B. Strömberg, P. Swings, O.C. Wilson, V. Kourganoff, J. Sahade.

In 1968, the topic of the 2nd Colloquium on Astrophysics was “Mass loss from stars” in the perspective of the fundamental space-UV observations of the following years. Important contributions were those by A.J. Deutsch, L. Houziaux, J.B. Hutchings, D.C. Morton, A. Renzini, W. Sargent, A. B. Underhill, J.P. Zahn, G.S. Mumford, T. Herczeg, B. Paczynski, M. Plavec, J. Ziolkowski.

In 1968 an updated version of the book “Le Nebulose e gli Universi-Isole” was published (Abetti & Hack 1968). Abetti died in 1982 at the age of 100.

The 3rd Trieste’s Colloquium on supergiant stars was held in 1971 (Hack 1972). Distinguished participants were: W. Buscombe, C.J. Butler, C. Fehrenbach, H. Lamers, J. Smolinski, J.B. Hutchings, P. Biermann, R. Kippenhahn, E. Meyer-Hofmeister, T. Lloyd Evans.

In 1969-1971 two Monographs of the project on “Stellar Spectroscopy” with O. Struve were eventually published (Hack & Struve, 1969, Hack & Struve, 1970). The project of a comprehensive treatise on “Stellar Spectroscopy” was started in the early sixties but was delayed due to the death of O. Struve in 1963. The manuscript remained in the hands of the publisher for quite a long time. Margherita, encouraged by Bengt Strömberg, finally decided to have the treatise published in Trieste and divided it into several sections .

Vol. 1 : Normal stars:

Stellar Atmospheres, Spectral classification, Stellar Rotation.

Vol 2: Peculiar stars:

Emission lines in spectra of hot stars, Be and shell stars, P Cyg Stars, Wolf Rayet Stars, Classical Novae and other explosive variables, Dwarf Novae, Supernovae, Magnetic stars, Chemically peculiar hot Stars, Metallic-line stars.

In 1978 the topic of the 4th Trieste Colloquium in astrophysics was “High Resolution Spectrometry” (Hack 1978) with notable contributions by R.M. Bonnet, D.

Gray, L. Gratton, K. Eriksson, M. Grewing, F. Praderie, R.N. Thomas, A.B. Underhill, D. Dravins, R.F. Griffin, Y. Kondo.

In 1985, the textbook “Corso di Astronomia” for her students at the University of Trieste was published (Hack 1985).

4. The first observations from space: the UV window.

Margherita Hack was on the front line of the Italian astronomers who recognised the importance of observations from space for the future of astrophysical research.

Space observations provided access to the hitherto unexplored UV range-window where hot stars radiate most of their flux and where both the resonance lines of the most abundant elements and many forbidden and inter-combinations lines of fundamental importance as diagnostics of temperature and density are present.

Margherita Hack was very active in promoting both the development and the participation in new scientific projects from space (TD1 S59, Copernicus, IUE).

TD1, launched in March 1972, was the first European satellite with two onboard experiments for UV astronomy: S2/68 and S59. S59 consisted in three spectral channels 100 Å wide, centered around λ 2110, 2550 and 2820 Å and resolution of 1.8 Å. TD1-S59 observed the binary β Lyrae and the study was published in a study by Margherita Hack together with van den Heuvel, Hoekstra and de Jager (Hack et al., 1976a).

A great advancement in the young UV astronomy was made with the launch of OAO-3 “Copernicus” in 1972. Copernicus had a clear aperture of 80 cm and was equipped with scanning spectrometers which allowed to obtain resolutions of 0.05 and 0.2 Å in the far UV (900-1560 Å, down to the Lyman limit) and of 0.1 and 0.4 Å in the near UV (1650- 3150 Å). Each scanning step registered in about 16 s a spectral interval of about 0.1 Å; this implied that a typical exposure time with good S/N ratio was on the order of several days. Copernicus was only able to study very bright stars and the ISM.

Margherita Hack obtained Copernicus spectra of β Lyrae, and published several contributions on its UV spectrum in collaboration with Hutchings, Kondo, Mc Cluskey, Plavec. (Hack et al. 1974, Hack 1974, Hack et al. 1975, Hack et al. 1976b, Hack et al. 1977). Margherita Hack obtained also Copernicus spectra of three early-type supergiants in Orion, β Ori, ϵ Ori, κ Ori, which were studied by her (then) young collaborators.

4.1. The International Ultraviolet Explorer (IUE)

January 26, 1978: the International Ultraviolet Explorer (IUE), a NASA-ESA-SRC project (Boggess et al. 1978) was launched in a geosynchronous orbit at 25,700 to 45,900 km from Earth: this allowed uninterrupted long exposure times. With SW + LW cameras it covered the λ 1170-3200 Å range at high (~ 0.15 Å) and low (~ 6 Å) resolutions. It was active until Sept. 1996. More than 100,000 spectra of celestial objects were secured in the course of 18 years.

Margherita Hack was the Italian representative in the ESA Astronomy Working Group during the whole lifetime of the Project and played a prominent role in the definition and scientific exploitation of the IUE satellite mission, especially in the selection of the Observing Programs.

In April 1978 Margherita Hack was present at the European ground-station of VILSPA (Spain) of IUE when ϵ Aurigae was observed. The first secured far UV spectrum showed clear evidence of the presence of a hot component in this binary system, a direct confirmation of the model that Margherita Hack put forward already in 1959 (Hack and Selvelli 1978; Hack and Selvelli 1979); see also the contribution by S. Ferluga in these Proceedings (Ferluga 2023).

4.2. The “fabulous four” : ϵ Aur, VV Cep, CH Cyg, and β Lyr

From the late seventies to the early nineties Margherita Hack published many studies

(Hack 1979, Hack 1981, Hack & Selvelli 1982, Hack et al. 1983, Ferluga & Hack 1985, Hack et al. 1989, Hack et al. 1992) about these “pathological” members of the zoo of interacting binaries, mostly based on UV observations with IUE complemented by ground-based observations taken at the Haute Provence Observatoire. These objects were like old friends to her. The UV data gave new impulse to the physical interpretation of these interacting binaries. They have it all:

1. High UV luminosity from the compact hot component
2. Giant - super giant companion: extended atmosphere, thick winds
3. Nebular-like conditions
4. Thick accretion disks : UV + opt. radiation
5. Surrounding shell
6. Circumbinary envelope
7. Dense and opaque dust torus : IR emission
8. Dust obscuration events
9. Bipolar jets
10. Colliding winds, shocks between jets and winds
11. X-ray emission

Thus, these systems represented convenient laboratories for the study of atomic and radiative processes in astrophysical plasmas.

5. The Monograph on “Cataclysmic Variables and Related Objects”

In the early eighties, the preparation of a comprehensive Monograph on “Cataclysmic Variables and Related Objects” was started, with M. Hack and Costanze La Dous as editors. The final version (Hack et al., 1993) appeared in 1993 as the eighth volume in a Series of Monographs by NASA-CNRS. The Series was inspired by R.N Thomas , L. Goldberg and J.C. Pecker as a modern counterpart of the Series of volumes on “Stars and Stellar Systems” published in the sixties by the University of Chicago Press. The monograph contained contributions by C. la Dous on dwarf novae and nova-like stars, by M. Hack, A. Bianchini, H. Duerbeck, M. Friedjung and P. Selvelli on classical novae and recurrent novae, and by M.

Hack, M. Friedjung and R. Viotti on Symbiotic stars.

6. Late Studies

Around 1995 M.H. went back to her favourite objects in the late fifties and early sixties: the chemically peculiar early-type stars, and in particular the problem of Lithium in the rapidly oscillating roAp-CP stars that exhibit short-period (few minutes) small-amplitude oscillations. This led to several publications in a broad international collaboration, in particular with N. Polosukhina, of the then ukrainian Crimean Observatory (Hack et al. 1997).

7. Other international activities

At the end of this review, one cannot but mention the twenty years of constant collaboration that Margherita Hack promoted with Professor Charles Fehrenbach and Dr. Yvette Andriolat, directors of the Observatoire de Haute Provence, where the optical spectra of her (and her collaborators') favourite targets were taken (Hack 1987).

Margherita Hack also fostered fruitful collaborations with international scientific institutions in France, Holland, Germany, Mexico, and Turkey, as well as with researchers from (then) "developing" countries.

In September 1974 the 2nd European Regional IAU Meeting was organized in Trieste with a valid contribution by Margherita Hack. The number of participants was 361 from 34 countries. The venue was the local University. Noteworthy invited papers by H. Habing, J.E Baldwin, I. Appenzeller, E.B. Jenkins, M. Grewing, T. de Jong, M.A. Dopita, L. Mestel.

8. Academic and scientific qualifications

A partial list of the most important scientific qualifications of Margherita Hack is reported here:

1. In 1980, the International School for Advanced Studies (SISSA-ISAS) was

founded in Trieste, with the support and patronage of Paolo Budinich, Director of the Institute of Theoretical Physics at the University of Trieste. Margherita Hack was member of the Astrophysics branch and was very active in the organization of the Courses.

2. Founder of the Department of Astronomy in 1985 at the University of Trieste and Director until 1997.
3. Director of the "Consortium for Physics" of Trieste.
4. Member of the Italian "Accademia dei Lincei", "Premio Linceo dell'Accademia dei Lincei" (1980) e "Premio della Cultura della Presidenza del Consiglio dei Ministri" (1987).
5. "Honorary Fellow" of the Royal Astronomical Society
6. "Honorary fellow" since 2003 of the Società Astronomica Italiana of which she was also Vice-president and several times member of the Board of Directors.
7. "Professor emeritus" of the University of Trieste in 1997.
8. In June 2012, at the age of 90, Margherita Hack received the title "Dama di Gran Croce dell'Ordine al Merito della Repubblica italiana" from the President of the Italian Republic.

9. Scientific outreach and divulgation

It must be emphasized that the general public's appreciation and recognition of Margherita Hack for her academic and scientific merits, (unlike other recognized scientists) were accompanied by an extraordinary popularity stemming from her strong and brilliant personality and from her outstanding contributions and dedications to scientific dissemination. For the general public she was the most famous Italian astronomer. Margherita Hack was highly appreciated by the Italian media, both for her enormous production of books and articles on popular astronomy and for her participation in hundreds of meetings and events with the general public where she presented the latest discoveries in astronomy and cosmology. Not to mention her social and political passion

in defence of the less fortunates, the environment, and of animals.

In 1979, together with Corrado Lamberti, she founded the well-known Italian divulgation magazine “L’Astronomia”, which later continued as “Le stelle”.

Margherita Hack contributed with many articles to *Sky & Telescope*, the famous American magazine for the divulgation of astronomy: in 1965 on the abundances of the light elements, in 1966 on the HR diagram, in 1967 on late type stars, in 1968 on the magnetic stars, in 1972 on the cosmic abundance of helium.

In Italy, Margherita Hack also promoted CICAP (Comitato Italiano per il Controllo delle Affermazioni sulle Pseudoscienze) an institution against pseudo-scientific statements, affiliated to the international CSICOP (Committee for the Scientific Investigation of Claims of the Paranormal). Hostile to any form of superstition, including pseudosciences, Margherita Hack was a scientific guarantor of CICAP since its foundation in 1989.

10. A final note

At the end of this overview, it is right and proper to recall that Margherita Hack, unlike other directors, was never a “boss” (or an Italian “Barone”). Probably mindful of her unpleasant experiences with her directors, she never forced her young collaborators to strictly follow her research line. As a matter of fact, she did not create a school of “clones”, but let her “seeds” germinate spontaneously on different but related topics of stellar spectroscopy.

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