



Working with Margherita

The strange Case of Epsilon Aurigae

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Abstract. I remind here my long scientific collaboration and personal friendship with Margherita Hack. She was an exceptional person, not only because of her well-known scientific and academic achievements, but also for her generosity and social commitment: athletics, politics, popular teaching, animal protection, were among her passions. The role of the inseparable husband Aldo in the life of Margherita is less known, but he contributed to any aspect of her work, even studies and books. I began my scientific career having Hack as Ph.D. supervisor at SISSA, in Trieste. She proposed to observe the 1982-84 eclipse of ϵ Aur, a unique naked-eye peculiar binary: so we discovered a multi-ring eclipsing disk. Similarly, at the beginning of her career, Hack detected a hot secondary companion (now to be located in the middle of the disk). During the 2009-11 eclipse, CHARA interferometer showed the dark disk passing in front of the primary supergiant star: the proof that, once again, Margherita was right.

Key words. Stars: Peculiar, Binaries: Epsilon Aurigae – Astronomers: Hack

1. Introduction

This short paper is not intended as being a biographical contribution about Margherita Hack (requiring much more space), and neither it is a scientific article about a star that we studied together (already published).

Rather, it should be regarded as a personal memory, trying to depict a portrait of this famous person, based on a thirty-years long life experience by one familiar friend and scientific collaborator.

Moreover, the Story of the involved persons (the family of Margherita and the Author's one), and the Star on study (Epsilon Aurigae), somehow are merged together.

2. The Story

The close collaboration and friendship with Margherita Hack covers the last tree decades of her life, starting from 1983 (when I got a permanent position as a researcher in the university of Trieste). My acquaintance with prof. Hack began even earlier, as a student of the Trieste University, when following her Astronomy course; then, I first became involved in scientific research when she was my Master supervisor at Sissa.

At that time, the 1982-84 eclipse of ϵ Aur was going on, a rare occultation event recurring every 27.1 years, caused by a spooky dark



Fig. 1. The star ϵ Aurigae, shining over the Dolomites, is marked by the arrow. This picture shows the nightscape as it is seen by the naked eye. Close to ϵ , another star incidentally shines just downslope on the mountain ridge (Sass Pordoi): that is ζ Aurigae. Such star was also studied by the Author, in a collaboration on interferometry (Di Benedetto & Ferluga 1990) suggested by Hack herself (photo: S.Ferluga).

object. This is the brightest peculiar star in the sky (the only one visible by unaided eye).

Moreover this is the star that a young Margherita observed much earlier, on the 1955-57 eclipse, inferring spectroscopically the existence of a hot companion (Hack 1959). Hence, Hack's idea was to verify such model, by using the IUE satellite to observe the current eclipse in the UV.

2.1. Friendship

So, to find myself in Spain observing at the Vilspa IUE facility – accompanied by my just-married wife Patrizia – it was then straightforward. Beside the fact that the hot component of ϵ Aur was confirmed (Boehm, Ferluga & Hack 1984), the presence of Patrizia opened a new dimension of familiar friendship in the working collaboration with Margherita.

In fact, Hack was a passionate defender of animals, and my wife (a teacher of classical

dance) was just the same. At home, both were taking care of injured dogs and dozens of cats, so they helped each other in this duty and in promoting animal rights.

2.2. Aldo

In parallel, a deep friendship raised among myself and Aldo de Rosa, the beloved husband of Margherita (backing her in all activities), as I was fascinated by his superior intelligence and encyclopedic culture.

It was Aldo himself, that involved a group of Italian researchers and colleagues around Margherita, promoting scientific and rational culture in the mass media. The commitment was to raise a strong skepticism against paranormal claims, astrology, occultism and pseudoscience.

Such a position was clearly against some widespread (but false) beliefs in the public opinion. So, that became the hard intel-

lectual mission of CICAP - the Italian version of CSICOP (Committee for Scientific Investigation of Claims of Paranormal) - for which I was the responsible, lasting more than two decades.

2.3. Margherita

Margherita Hack, always defending the rights of the oppressed people, was also a popular and simple-minded political activist in the left-wing parties. She was even elected as a deputy in the Italian Parliament, but then she gave up, in favour of teaching and research.

Moreover, she was a convinced atheist and feminist already in her youth, promoting ideas that were strongly opposed at that epoch, as instead they are fully accepted nowadays. Always coherent with her principles, not only in her best-seller books and talks, but also in her simple and generous way of life, Margherita stood always "one step forward" in the development of thought and Ethics.

The evolution of our society, during half a century, finally proved that she was right fifty years in advance.

3. The Star

On the scientific side, during the 1982-84 eclipse we performed high-resolution spectroscopy in the ultraviolet, and also in the visible range at the Observatoire de Haute Provence (Ferluga & Hack 1985).

The rarefied shell of excited gas, rotating around the hot secondary star, was then studied in depth (Ferluga & Mangiacapra 1991). Velocity curves and temperature profiles were finally derived for this envelope, which is another component of ϵ Aur that was inferred by Hack as well, long ago (Hack 1959).

At those times and earlier, besides Hack, there were many other authors that previously suggested strange models for this unique peculiar binary. The long-standing problem remained that, anyway, no one knew the true nature of the dark object, causing the primary eclipse.

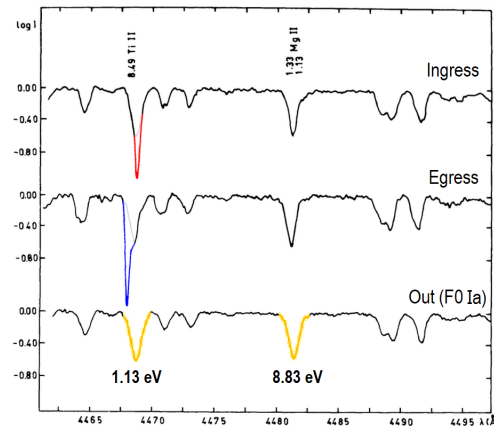


Fig. 2. The shell spectrum is shown here at high resolution (Ferluga & Hack 1985). During the eclipse, sharp Doppler-shifted absorption components appear, due to the rotating gaseous shell of the secondary. Above: on ingress phase, the shell line is receding (shown in red). Middle: on egress phase, the same component is approaching (shown in blue). Below: out of eclipse, only the primary spectrum (F0 Ia) is present. Note the two lines with same profile, by different elements (in yellow): only the low-excitation line displays the shell component.

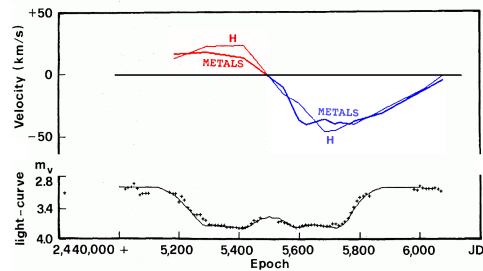


Fig. 3. The rotation of the gaseous envelope around the secondary star was studied, by measuring the velocity of the shell lines with respect the primary spectrum. The black line below is the light-curve, showing the corresponding eclipse phases. Peak velocity of Hydrogen is slightly higher than Metals.

3.1. The Disk

Which kind of mysterious "thing" was really producing the eclipse? Here comes the final part of our almost life-long investigation (given the period of this exceptional binary), inspired by Margherita and completed by myself.

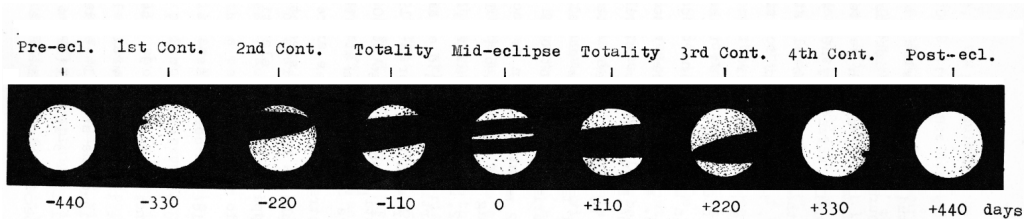


Fig. 4. The changing aspect of the eclipse of ϵ Aur at different phases, expected from a ring-like disk transiting obliquely in front of the primary star (dots indicate the gaseous envelope). This was the earliest sketch of the eclipsing body (Ferluga 1987), hand-made, but exactly confirmed by modern interferometry.

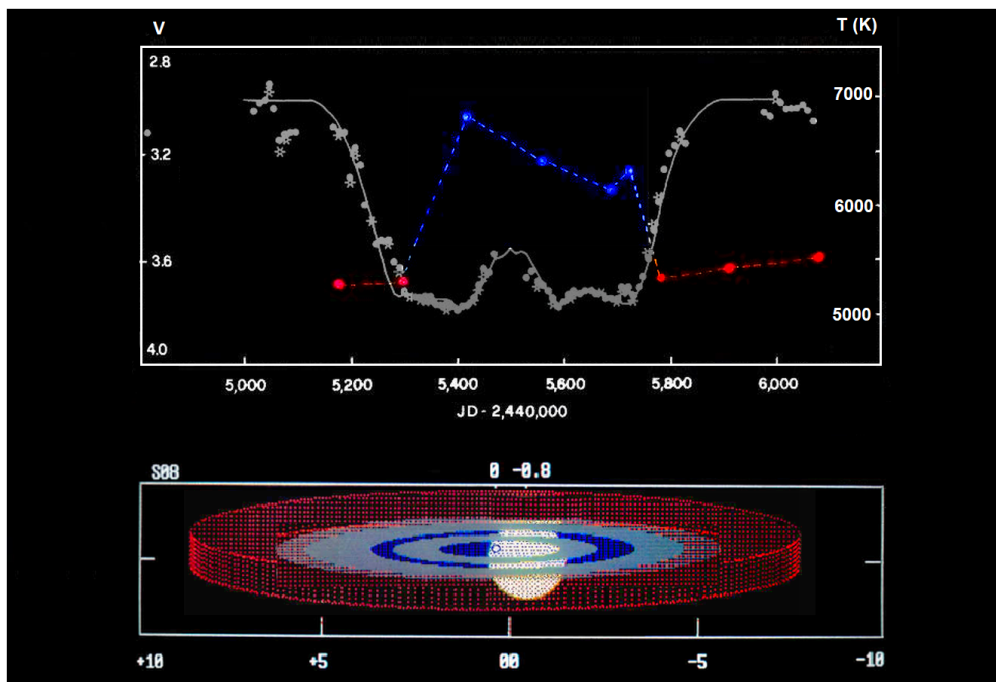


Fig. 5. The secondary component of ϵ Aur is a complex object. The upper panel shows (together with the light-curve) the observed temperature of the gas inside the envelope, rising from 4000 K at the edge (red) to 7000 K in the middle (blue). The lower image is the output (on the computer screen) of the model reproducing eclipse. The opaque disk (grey rings) transits rightward, while it rotates counter-clockwise; the dotted "cake" is the shell of gas, with its warm (red) and hot (blue) regions.

The right answer was found by modelling the light curves published in the literature, with eclipsing bodies having different geometries. (Ferluga 1989) An almost perfect fit was given by a large multi-ring opaque disk, with a central hole (accounting for the observed brightening at mid-eclipse). The disk is seen with a strong inclination (almost edge-on), while

it transits obliquely in front of the big primary supergiant, partially occulting its surface (Ferluga 1990).

So, we were finally able to understand that the he gaseous shell and the opaque dusty rings, orbiting around a hot dwarf star, form the complex structure of the eclipsing component of ϵ Aurigae.

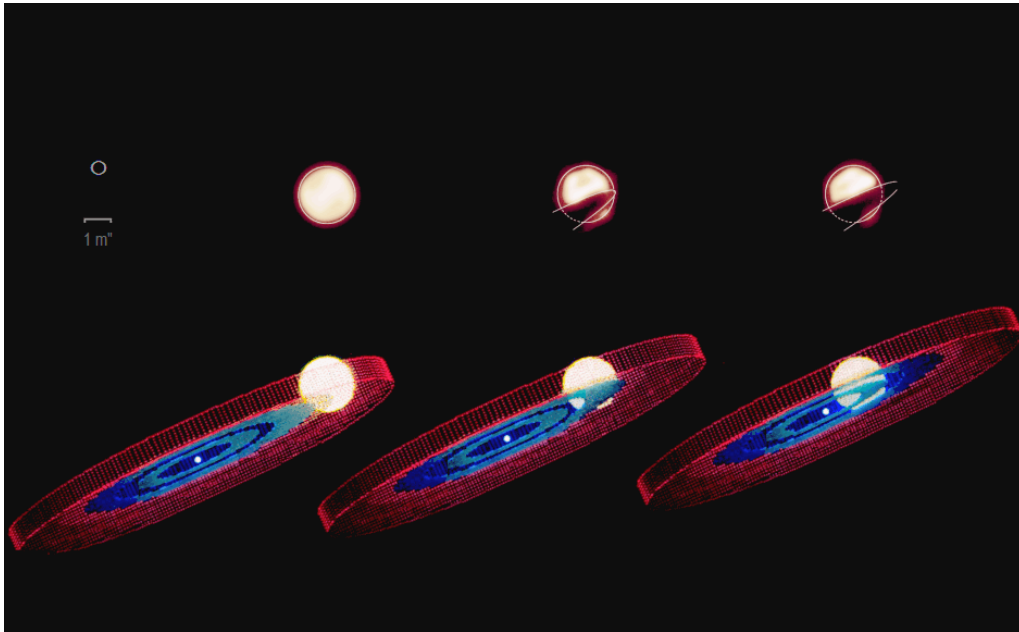


Fig. 6. Comparison between the occultation observed by CHARA (above) and the prediction of the model (below). The agreement is spectacular!

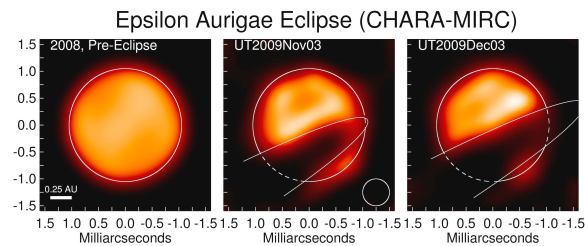


Fig. 7. The astounding images of the eclipse of ϵ Aurigae, directly observed by the CHARA interferometer (Kloppenborg et al. 2010), during the phase of ingress on 2009.

Interestingly, while transiting over the bright photosphere of the primary star, this interposed body performs some kind of “tomography” of itself, thus providing plenty of information.

3.2. The Proof

However, up to this point, the various objects really composing ϵ Aur – luminous F supergiant, eclipsing secondary (B dwarf with surrounding disk) and envelope – could only be inferred or theoretically modelled.

The ultimate confirmation of the true structure of ϵ Aur came twenty years later in 2009, when astronomers of CHARA (Center for High Angular Resolution Astronomy) observed the new eclipse by interferometry, and obtained astounding images (Kloppenborg et al. 2010)

When looking at those pictures, now everybody can see the the elongated shadow of the inclined disk, projected onto the surface of the supergiant, occulting progressively the star. Here stays the final proof that, also in such case, Margherita was right.

4. Conclusion

It happened in this way, that my personal research in Astronomy started by detecting the eclipsing disk and rings, from the photometry of the 1982-84 eclipse. This raises a curious parallelism with the beginning of Margherita's career, when she also observed ϵ Aur, detecting the secondary star and envelope, from the spectroscopy of the previous 1955-57 event.

Strangely enough, when Margherita Hack was asked by the Italian television about the most exciting discovery of her entire life, she answered it had been Epsilon Aurigae. It means that we both were life-long fascinated by this beautiful celestial object; in fact, the same thing holds also for myself: deep in my heart, Epsilon Aurigae remains "my star".

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