

Fall and raise of Betelgeuse in 2020

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Abstract The minimum of Betelgeuse in February 2020 received very much attention by the media, well beyond the astronomer's community, because many have used, improperly, the argument of supernova to deal with this phase of the light curve of the star. As a theoretical astrophysicist, member of the International Center for Relativistic Astrophysics and AAVSO member for the community of variable stars observers I decided to participate to the debate about Betelgeuse in early 2020 either on the media side, by criticizing some choices of communication, either on the observative side, by contributing with accurate visual observations rooted strongly on a long tradition of accuracy. Betelgeuse has been in my observative program since December 2011, mainly because it was always accessible from Northern and Southern hemisphere, and from large cities, light-polluted environments, where I leaved and studied (Roma, Paris and Rio de Janeiro). The novelty of the paper, after an autobiographical introduction, is the rapid recovering of the maximum luminosity of Betelgeuse, already verified in the first decade of April 2020, only about 40 days after the historical deep minimum of February.

Riassunto

Dopo il profondo minimo di Febbraio 2020, quando Betelgeuse è sceso alla magnitudine 1.45 visuale, la stella ha recuperato rapidamente luminosità e per la fine di marzo – inizio aprile è ritornata alla magnitudine usuale di 0.45. Con un Astronomer's Telegram del 31 marzo avevo comunicato che la velocità di risalita della luminosità era alta, e avevo anche fornito un modello predittivo di tipo “cinematico”, e cioè se questa sarà la velocità massima, la luminosità massima sarà attorno alla magnitudine 0.4. Si tratta di una previsione “cinematica” perché non entra nessun modello astrofisico o geometrico: soltanto un modello armonico di oscillazione, cioè un'oscillazione avviene tra due estremi ai quali la velocità di cambiamento (in questo caso della luminosità) si azzera; a metà tra gli estremi la velocità è massima. Poiché il 31 marzo la velocità di cambiamento era già attorno a 0.02 magnitudini/dì, e la luminosità valeva 0.90, si poteva pensare -per la ragione suddetta- che questo fosse il valore intermedio della luminosità e 0.4 potesse essere il successivo massimo. Questo modello predittivo, contenuto nell'ATel, non svelato neppure in questo articolo uscito nella ICRANet newsletter, a fine maggio 2020 sembra confermato dai dati che ho continuato a prendere sulla luminosità di Betelgeuse, che si è attestata attorno a 0.5.

Nell'articolo richiamo la storia delle mie osservazioni di stelle variabili, che dal 1997 a oggi sono quasi 2400, in cui inquadro le quasi 700 dedicate a Betelgeuse dal 2011, ed anche il meeting internazionale organizzato per il 17 gennaio 2020 all'ICRANet di Pescara



Introduction

Betelgeuse, the supergiant star alpha of Orion is a semi-regular variable star, ranging normally between 0 and 0.9 magnitude. In 2019/2020 it reached a visual minimum of 1.45 mag around 11th february, and by 12th april it is already at mag 0.45.

The attention of the astronomical world on this phenomenon was relevant, but none of the media dedicated were able to evidence the unproper quoting of a supposed pre-supernova stage.

A meeting on January 17th in Pescara ICRANet seat was organized to comment these news and the last observations show a rapid restoring of the usual luminosity of the star.

Visual observations of Variable stars since 1997 with Mira Ceti:

On December 6th 2019, after more than one month of cloudy nights over Rome, Betelgeuse was estimated by me as 1.1 visual magnitude, getting the lowest value of AAVSO records. AAVSO is the American Association of variable Stars Observers and it has thousands affiliated.

During a science visit as ICRA member in Fermilab and ESO/Chile in 1999 I had the first possibility to observe Eta Carinae, the supergiant star that had a outburst in 1843, to negative magnitude, becoming the second star of the night sky, only inferior to Sirius and Canopus. This observation was done in Santiago de Chile at ESO headquarters where I gave a talk on Fermions in the Early Universe, the subject of my first PhD, and it was the occasion to become an AAVSO contributing observer, with the code SGQ. The enrollement on the internet was done in the bureaus of prof. Teitelboim, I was visiting.

In the same year, 1999, in July when the Nova Aquilae 1999 was measured from Pescara ICRANet seat, we obtained an acknowledging diploma from Janet Mattei, the former director of AAVSO, untimely dead in 2004. My research project in variable stars begun in 1997 with my history of science studies about the Bethlehem star, made for the master's degree in Theology at Lateran University (Rome, 1998). I explored the hypothesis that Mira Ceti could have been that star.

Mira is close to the position where in the year 6-7 b.C. Jupiter and Saturn



had the triple conjunction calculated already from Kepler in 1611. Kepler added that this conjunction could have been the cause of the new star, which should have been the Bethlehem star. The connection between Mira and the Bethlehem star was possible because of my series of observations of Mira in 1997, made for understanding the appearance of a variable star, and the method of observing with naked eyes (Argelander's method and airmass correction). This is for presenting my 23-years experience in observing variable stars.

In Marcel Grossmann Meeting XIV of 2015 and XV of 2018 I have presented two talks dedicated to 1) to the first 1000 observations 2) to Betelgeuse visual observations compared to V-band digital data realized in Wien by Wolfgang Vollmann for the same time period: from 2011.

The historical minimum of 2020

On december 8th E. Guinan of Villanova University started a series of Astronomer's Telegrams dedicated to the unusual fading of Betelgeuse. I attended the 29th of december 2019 to prepare a communication to arxiv.org appeared on January 1st 2020, dealing with the Historical minimum of Betelgeuse, about to end. The date of the minimum was predicted "by february" simply by analyzing the last 8 years of homogeneous observations made by me and Vollmann (SGQ and VOL) already published in MGM XIV and updated to end 2019.

The ICRANet meeting on Betelgeuse dimming on 17 January 2020

Another occasion to study the behaviour of Betelgeuse was created by the interaction held with Margarita Karovska of Harvard CfA who read my arxiv and commented it via e-mail: we decided to organize a virtual meeting with the most prominent italian experts of Supernovae and Observational Astronomy and the AAVSO director Stella Kafka. The Meeting was held in Pescara, ICRANet seat on January 17th.

My first goal was to remind the public opinion that a Supernova is the result of a core collapse in a free-fall time, that for a 12 solar mass star does not excess some tens of minutes, not months, as the news from several media were diffusing.



Cesare Barbieri, Massimo Turatto and Paolo Ochner of Padova University and Asiago Astrophysical Observatory, the major in Italy added their contribution to that succesfull meeting, chaired by prof. Ruffini and me.

On February 2nd on AGB newsletter of the IAU division on Red Giant Variable stars, I sent my contribution for the Question of the Month "When Betelgeuse will explode? And it has been reported in full detail, with the aforementioned goal of the ICRANet meeting of 17th January.

Rapid rising of the light curve of Betelgeuse in march-april 2020:

On March 31st I have published the Astronomer's Telegram #13601 regarding the rapid rising of the light curve of Betelgeuse, attaining already 0.02 magnitudes/day and 0.9 visual magnitude, with an increase of 0.55 magnitudes since 11 february 2020, when the minimum was reached, with 1.45 visual magnitude. I wrote that if this will be the fastest rate it would have been reasonable a maximum around magnitude 0.4, with a very simple kinematic model: the largest speed is found at the center of an oscillation.

Now, 12 april 2020, the magnitude is reaching already 0.45 visual magnitude with an average rising velocity of 0.45 mag/12 days or 0.0375 mag/day during the last two weeks. A simple extension of the kinematic model would consider this one as the new center of the oscillation, but it cannot be, implying a negative magnitude maximum, which would be really unprecedented.

The basic idea proposed since 1984 by Margarita Karovska and treated once again during our ICRANet meeting of 17th January is that there are dust clouds around the star which can either dim the light from the photosphere, either diffuse it through backward scattering when the cloud is behind the star. The observations to be realized in these days by the ESO VLT interferometer can confirm this hypothesis. The last published ones, available in the Astronomer's Telegram references in my #13601, show Betelgeuse at minimum, as consisting in a photosphere divided in two regions, one of which is much darker than the other, because behind the aforementioned cloud of ejecta. Now this cloud is possibly moving to the back of the stellar photosphere, contributing to a maximum even brighter



than usual values and approaching to magnitude 0. We have to expect new data to complete this noteworthy cycle of Betelgeuse.

Conclusions:

The last one data on which I based the ATel #13601 have been taken from Rome, near the Vatican, by using the naked eye technique developed in these last two decades to solve the problem of lack of nearby comparison stars for such bright variable star. Differential photometry is impossible and the different altitude of the comparison stars has to be measured to compute the airmass contributions for each star (Betelgeuse, compared with Pollux and Castor during the minimum phase and compared with Procyon and Aldebaran during the present phase, or Procyon and Rigel during maxima).

This technique is a basic one in photometry, but it is not mentioned in visual observations. I have done it with several high school students of Rome and Pescara and through specialized publications.

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