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Mg II chromospheric emission line bisectors of HD39801 and its relation with the activity cycle

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Abstract

Betelgeuse is a cool star of spectral type M and luminosity class I. In the present work, the activity cycle of Betelgeuse was obtained from the integrated emission flux of the Mg II H and K lines, using more than 250 spectra taken from the International Ultraviolet Explorer (IUE) online database. Of which it was found, based on a Lomb Scargle periodogram, a cycle of 16 years, along with 2 sub-cycles with a period of the order of 0.60 and 0.65 years, which may be due to turbulence or possible stellar flares. In addition, an analysis of line asymmetry was made by means of the chromospheric emission line bisectors, due to the strong self-absorption observed in this lines, the blue and red wings were analyzed independently. In order to measure such asymmetry, a "line shift" was calculated, from which several cycles of variability were obtained from a Lomb Scargle periodogram, spanning from few months to 4 years. In the sense, the most significant cycle is about 0.44 and 0.33 years in the blue and red wing respectively. It is worth noting, that the rotation period of the star doesn't play an important role in the variability of the Mg II lines. This technique provides us with a new way to study activity cycles of evolved stars.

1 Introduction

Magnetic fields in single evolved stars are still poorly studied. This is because we expect that with the evolution of the star the magnetic field weakens or, in the worst case scenario, disappears. One of the phenomena that strengthens the magnetic activity is the differential rotation within the star. Most of the stars with spectral type G, K and M, that are known to be active, are also fast rotators. Angular momentum dredge-up has been suggested to provide the fast rotation, driven by the convective zone reaching near the stellar core. In this way, magnetic fields could be generated by a new dynamo, Konstantinova-Antova et al. (2009)

The chromosphere allows us understand the evolution in different phases of the star, and the mechanisms present in each phase. One of the relations between the age, activity and rotation is the Skumanich law, Skumanich (1972), this law describes how the emission flux changes according to the rotation of the star. So that is how the stellar age is involved, since the star evolves the rotation speed decreases, and, since the rotation strengthens the magnetic field, it is expected also to decrease.

One way to measure the stellar activity of the chromosphere is through the line asymmetries, as we know this exists in stars generally F,G and K. The line bisectors, as a measure of line asymmetry, is a consequence of mass movement, turbulence and also stellar winds, the last ones are directly related with stellar magnetism. In the figure 1 we show an example of a bisector line found in the Mg II (h+k) lines of Betelgeuse, the spectra was taken from the online database of the International Ultraviolet Explorer, IUE. Betelgeuse (HD39801) is a supergiant with spectral type M.

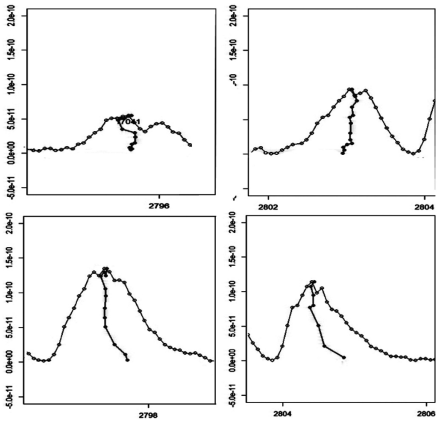

Figure 1: An example of the Mg II h and k line bisector obtained for each spectra in the sample

2 Methodology

The method that we used to calculate the activity cycle of Betelgeuse is based in the measurement of the Mg II h and k emission flux lines. We take 250 observations of Betelgeuse from the online database of the IUE these spectra were recorded since 1979 to 1996. Only 165 were used since the exposure time was very high in some cases, causing spectra to over saturate making it impossible to apply the same method for measure the line variability or integrated flux. In figure 2 we can see one of the typical Mg II h and k line. The activity cycle of Betelgeuse was obtained from the integrated emission flux lines Mg II H and K, and the bisectors method was used to find the variability between red and blue wings. Based on

a periodogram of lomb Scargle we found the cycles and sub-cycles of the star.

3 Results

The figure 3 represents the measurements of the integrated emission flux at the Mg II (h+k) for each spectra available in the IUE online databse, in which itcan be observed variability in time. As we can see in the figure 4 we found, based on Lomb Scargle periodogram, a cycle of 6.47 years, also we found 3 sub-cycles which may be due to turbulence or possible stellar flares, having a period of 3.04, 2.48 and 1.93 years. In addition, a bisector analysis was made for the chromospheric emission lines Mg II H and K, due to the strong self- absorption the line profile had to be analyzed separately by the blue and red side of each line. We found 9 cycles of variability by means of the same technique mentioned above, in this periodograms we cannot see a relation between the rotation period of the star (or a planet), thus this variation found in the bisectors its due to something else. These cycles are shown in figures 5 and 6 which have a period between 1.05 and 6.38 years. However, it is worth noting that only the k line show this variability, and it is not clear the phenomena behind it.

4 Conclusions

As we can see the activity cycle of Betelgeuse was determined from the Mg II chromospheric emission flux, along with another two sub cycles. This result is an indicator of stellar activity present in Betelgeuse. However, the cycles found still need further research, in the sense that we still do not know why these cycles occur.This technique provides us with a new way to study the stellar activity of evolved stars.

References

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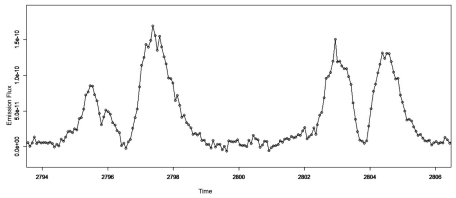

Figure 2: An example of the Mg II (h+k) line from the IUE spectra.

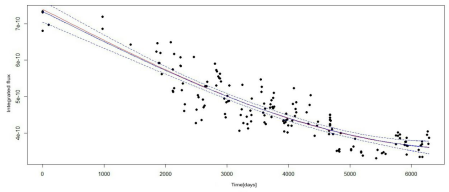

Figure 3: Mg II (h+k) integrated emission flux over the observing period.

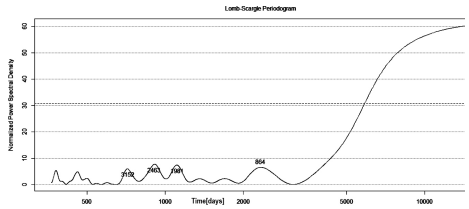

Figure 4: Lomb Scargle periodogram of the Mg II (h+k) emission flux, where 4 cycles are displayed.

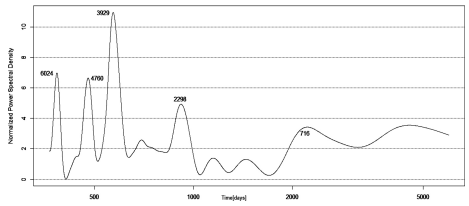

Figure 5: Sub-cycle of Betelgeuse found in the blue wing K

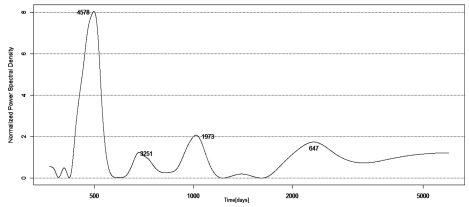

Figure 6: Sub-cycle of Betelgeuse found in the red wing K