The space photometry revolution in our understanding of RR Lyrae stars

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Abstract

The Blazhko effect is the conspicuous amplitude and phase modulation of the pulsation of RR Lyrae stars. It had been discovered in the early 20th century and constitutes one of the longest standing problems of stellar pulsation theory. The field of study of this mysterious modulation has recently been invigorated thanks to the long, quasi uninterrupted, ultra-precise space photometric time series data. It turned out that if we look at RR Lyrae stars through the optics of CoRoT and Kepler space telescopes, we can discern a fascinatingly diverse collection of dynamical phenomena that has been completely unknown before the space photometry era. In this talk I will give an overview on the latest observational findings delivered by both CoRoT and Kepler. Then I will discuss how space photometry results have advanced our theoretical understanding of RR Lyrae stars.

By analyzing long time series data, it is now obvious that more than 60% of the Blazhko stars feature multiple modulations, with some hints of low-dimensional chaos in a few cases. Most importantly, we found period doubling in the majority of the Blazhko-modulated Kepler and -most recently- in CoRoT stars. This discovery offers a new handle on the tough Blazhko-problem, since we were able to prove that the origin of the period doubling is a high order resonance between radial modes. What is more interesting: by using the amplitude equation formalism, it can be shown that the same resonance is able to create the modulation itself, which can be either regular, irregular (multiply modulated) or even chaotic. Thus, the radial resonance model is currently the most plausible explanation to this century-old enigma.

If more than two modes are present in a nonlinear dynamical system such as a high-amplitude RR Lyrae star, the outcome is often an extremely intricate dynamical state as is confirmed by our hydrodynamical models. It is important in this context that we identified high radial overtones, high-order resonances, other resonances and triple-mode pulsation states in the analyzed data. We found pieces of evidences for temporal variations of these additional frequencies in most of the cases. These surprising discoveries have profound consequences on our understanding of the mode selection mechanism and the interaction between pulsational modes.

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