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On the question of detecting granulation signal in CoRoT light curves of A and B stars

*S. Ghazaryan**

Byurakan Astrophysical Observatory, Aragatzotn Province, Byurakan, 0213, Armenia
LUTH, Observatoire de Paris, 5 Place Jule Janssen, 92190 Meudon, France

We applied the procedure written by us to HgMn targets observed both through CoRoT astero and exo channels to check its usefulness for search of possible existence of solar-type granulation signature in their power spectrum. The point is that many articles appeared very recently considering this problem but, we did not find any paper on this issue in relation to chemically peculiar main-sequence stars. Because theoretical models based on atomic diffusion require that the atmospheres of ApBp stars have to be more stable than those of normal stars, presence or absence of granulation on their surfaces should be an interesting information for modelling. The earliest results show that our method is appropriate for analysis of data obtained through astero and exo channels. Nowadays, solar-type granulation effect most likely has not be seen within CoRoT data for the stars we considered. This issue needs further consideration.

Key words: asteroseismology, HgMn stars, granulation

INTRODUCTION

CoRoT (Convection, Rotation and Transits)[1], a satellite with 27 cm mirror, was successfully launched on the 27th of December 2006. This instrument allows to probe stellar interiors via variations of the light curves which can be studied using the frequency spectra. It provides a tool for deeper understanding of internal structure of stars. Namely, if a large number of modes penetrating to all possible depths can be observed on the surface, than it is possible to "invert" the observations to make a map of the sound speed throughout the star, and then to deduce the temperature profile, with reasonable assumptions about the chemical composition. Thus asteroseismology lets us literally to see the interior of stars because different modes penetrate to different depths. With the data obtained through CoRoT Astero channel we are able to study the modes more carefully, to do frequency Fourier analysis which allows us to have some idea about signature of solar granulation effect in many stars. Granulation, as we know, is a result of convection motions leading to upward flows of hotter plasma and downward flows of cooler plasma.

The discovery of global oscillations in the Sun by Claverie et al. in 1979 [2] and Grec in 1980 [4] opened a way for the new solar observations, for measuring, for example, the depth of solar convection zone and rotation of the Sun at different depths and latitudes. However, there is still a debate on the question which type of oscillations can be hidden by stellar granulation and the examination of solar granulation effect signature is not well done. Solar-like oscillations have been detected from the ground in radial velocity in several stars but because of high uncertainties of the ground based observations it is preferable to do high-precision photometry from the space. In 2008 CoRoT team announced detection of the solar-like oscillations and granulation in stars hotter than the Sun. In the paper, published in Science, they claim for the presence of these effects in three main-sequence F-type stars (see [9] for more details). The solar granulation frequency reaches up to 2 mHz for all of them. In 2010 Kallinger and Matthews [6] announced possible existence of solar granulation in early A-type stars. They presented evidence for this effect in two δ Scuti stars of spectral type A2: HD 17493 and HD 50844. That is why we decided to search for signature of this effect also in HgMn stars.

HgMn stars are the late B-type Chemically Peculiar stars, the effective temperature of which is ranging from 10 000 K and 16 000 K. They are characterized spectroscopically by large overabundances of Hg (possibly up to 6 dex) and Mn (possibly up to 3 dex, [1]). Overabundances greater than 2 dex of Be, Ga, Y, Pt, Bi, Xe, Eu, Gd, W, and Pb are frequently observed in these stars, while He, N, Mg, Al, Ni and Zn often are underabundant by more than 0.5 dex

*satenik.ghazaryan@obspm.fr

[1]The CoRoT space mission is developed and operated by the French Space Agency CNES, with participation of ESA's RSSD and Science Programmes, Austria, Belgium, Brazil, Germany, and Spain.

[10]. The elements C, O, Si, S, Ca, V, Cr and Fe usually show only modest peculiarities, with abundances within 0.5 dex of their solar one (classified as "normal type" elements in [10]). HgMn stars are slow rotators, often binaries, and the existence of a weak magnetic field in their atmospheres is still a subject of debate. Because of their high effective temperatures, the HgMn stars should not host hydrogen convective zones in their envelopes, and their low He abundances may reduce the importance of He convective zones as well. Such a quiet external layers allow atomic diffusion to proceed and hence to explain the observed abundance anomalies [8]. The absence of granulation in HgMn stars will give a new way to prove the absence of convection zones in these stars which is extremely important for understanding the inner structure of these stars.

SELECTED TARGETS AND ANALYSIS

The first step of analysis was to select a target which was observed by CoRoT Astero channel. The selected target is HD 175640 (the CoRoT ID is 7569). It was observed in 2008 during the SRc02, which means that the observations were done during the second Short Run to the Galaxy centre direction. This is a bright B9-type star with 6.21^m apparent magnitude and it belongs to the third Luminosity class targets. The light curve of CoRoT7569 is a combination of strong trends and weak jumps (Fig. 1). The raw light curve of CoRoT7569, which was obtained using our own procedure [3] written in `IDL` language, does not show any transits (Fig. 2). It is well detrended and there is no clear evidence for granulation. To prove the absence of signature of solar granulation in HgMn stars we calculated the power spectrum of the light curve using `Period04`, software written by Lenz and Breger in 2005 [7]. And then, the same calculations were performed for the original light curve. These two spectra are presented in Fig. 3. The CoRoT orbital frequencies are also overplotted on the graph.

To calculate the solar granulation frequency we used the second equation given in [6]:

$$\nu_{gran} \propto \nu_{max} \propto M \cdot R^{-2} \cdot T_{eff}^{-1/2}, \quad (1)$$

where the mass, radius and effective temperature are taken in solar units.

Assuming that

$$M/M_{\odot} = 3.36, \quad R/R_{\odot} = 2.55, \quad T_{eff}/T_{eff,\odot} = 2.03, \quad (2)$$

we mean that granulation frequency is $\nu_{gran} \sim 440\,\mu$Hz. As one can see from in Fig. 3 there are no changes in the spectrum. It is almost flat which means that there is no sign of granulation.

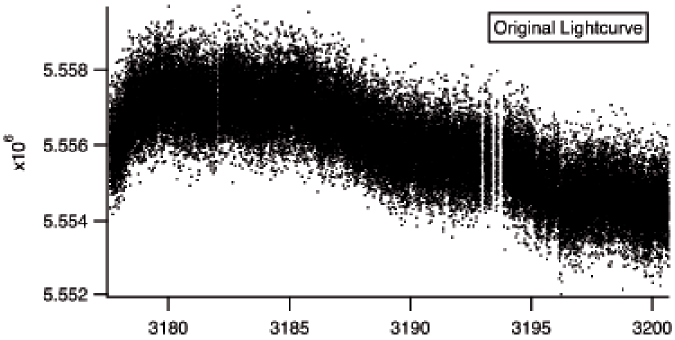

Fig. 1: Original light curve of CoRoT7569 obtained through CoRoT Astero channel.

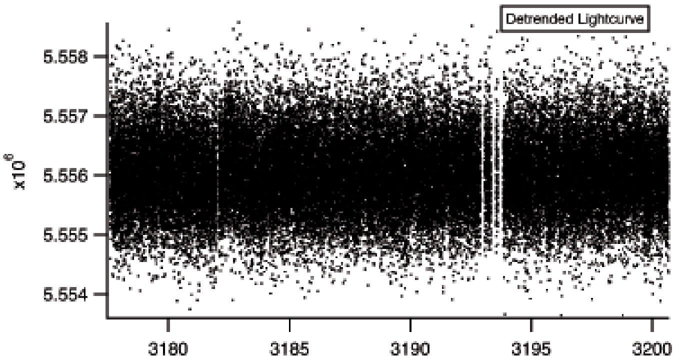

Fig. 2: Detrended light curve obtained through ColigCor.

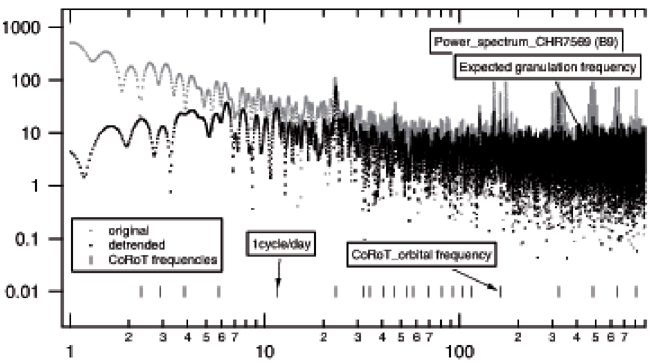

Fig. 3: Power spectra of the original and detrended CoRoT7569 calculated with Period 04. The grey and black curves correspond to the original and detrended light curves, respectively. The frequencies marked below the diagrams present the CoRoT orbital frequencies.

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