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Review of the doctoral dissertation by Sumanta Kumar Sahoo titled „TESS photometry of hot subdwarf stars"

The doctoral dissertation prepared by Sumanta Kumar Sahoo addresses an important topic in stellar astrophysics, namely the pulsational characteristics of hot subdwarf stars.

The dissertation consists of six chapters: the first one introduces the reader to the general properties of hot subdwarf stars and briefly summarizes the main scientific results of the thesis, while the following five chapters are identical with peer-reviewed articles published in MNRAS (Papers I-IV) and PASA (Paper V). Sumanta Kumar Sahoo is the first author on four out of five articles (Paper I and Papers III-V) and is the second author on Paper II, where his contribution to the publication is nevertheless very high (estimated at 65%). This shows his ability to lead and publish high quality research, which is an indication of his maturity as a scientist. The published articles have been cited 54 times in total as of writing this review, which, given the fact that two papers are very recent (from 2023 and 2024), is a very good result, proving that the undertaken research topic is significant.

Paper I and II present the results of the search for pulsating sdB stars (sdBV) in 30 min full frame images from the TESS all-sky survey in the southern (Paper I) and northern (Paper II) ecliptic hemispheres. The importance of this study is that this is the first attempt to find sdBV stars in a homogeneous all-sky data base, whereas previously discovered sdBVs come from various ground and space-based observations, meaning they cannot be used for general sdBV population studies, especially the ones involving their spatial distribution within the Milky Way, where the different chemical compositions may help understand the hot subdwarf pulsations.
In the course of this time-consuming study 15 new pulsating sdB stars were found in the all-sky data base, compared to 130 sdBV previously known. In total, 2313 variable stars were identified, 113 of which might also be sdBVs, since they show signal in the g-mode region of the amplitude spectrum.

Given the large pixel size in TESS, which is 21x21 arcsec, there are often additional stars within the pixels in which the variable stars were found. Therefore, in Paper III, the authors focus on verifying whether the variability comes from the sdB star and/or one or more of its close neighbours. In result, 7 out of 15 sdBV stars from Paper I and II have been reclassified or uncertain, leaving 8 confirmed sdBVs. From the total of 2313 variable sdB stars, 721 maintained their variable status, and additional 682 variables were found among the target neighbours. For likely pulsators, 10 min full frame images were analyzed and the signal of g-mode pulsations was detected in amplitude spectra of 11 sdB stars.

Paper IV contains the detailed pulsation mode analysis of three sdBV stars observed by the early TESS mission. Two were found to be g-mode pulsators, while one is a likely hybrid pulsator showing both g and p-modes. Paper V presents a similar analysis for six g-mode sdBVs based on the short and ultra short cadence TESS observations from the second cycle. The mode identification in both studies was based on the period spacing method, since the amplitude spectra did not reveal any multiplets. Using the period fitting technique the authors determine physical parameters of six sdBVs from Paper V and found them to be consistent with theoretical predictions.

The relation between pulsations in sdB stars and their helium content was investigated in Paper V and the authors found that helium-rich hot subdwarfs are much less likely to pulsate than helium-poor ones. In terms of the location of sdBVs in various Galactic environments, the preliminary results show that both g- and p-mode pulsators are found in the thin and thick disk and the halo, although there seems to be more p-mode pulsators in the Galactic halo than in the disk. However, given the small sample size, these results should be treated with caution.

The thesis, including all published articles, is well written and so is a pleasure to read, with only a handful of spelling errors throughout the text, the most conspicuous ones being “hor” instead of “hot” subdwarfs occurring twice in the Abstract. The errors in the Polish version of the Abstract are understandable given that the author does not speak Polish, but nevertheless it was surprising to me that the most obvious ones slipped unnoticed, e.g., the very fist words of the Abstract being “Nasz badania” instead of “Nasze badania”.

The dissertation is composed of publications that have already been refereed. Therefore I only have a few comments, mainly to Papers I-III, since I lack expertise in pulsation mode analysis presented in Papers IV and V:

1. When reading the Introduction I was missing an illustration showing the location of the hot subdwarf stars in the HR diagram, which would nicely complement the description of subdwarf properties in Chapter 1.1.
2. It is not clear to me how exactly the selection of sdB candidates was performed. In Paper I and II the authors state that the candidates were selected from the sdB data base compiled by Geier (2020), which contains 39 800 stars. Then in Paper III a different number is quoted when citing Paper I and II, namely 45 674. However, the published catalogue of Geier (2020) contains 5874 sources and I did not see an information about a different, broader list in their publication.
3. It would be interesting to see an information about the sdBV detection efficiency in full frame images (Paper I and II). This could be quantified by verifying how many of the 130 sdBVs known prior to this study were recovered from the full frame images, taking into account only those that could have been recovered (I understand that the analysed TESS data allows for the g-mode detection only).
4. In Paper III, 10 min FFI data for 78 most likely sdBVs were analysed. In result, sdBV status was confirmed for 11 stars. Does this list include 8 sdBV found in Paper I and II (7 were removed from the original list of 15), or are these additional discoveries? In other words, did the list of 78 targets chosen for further investigation contain sdBV discoveries from Paper I and II?
5. Regarding the spatial distribution of sdBVs in the Milky Way (Paper V) – what are the typical distances of these sdBVs? Are they within the range where Gaia distances are considered reliable? And consequently, what is the accuracy of determining the membership of individual sdBVs to the Galactic populations?

6. In Paper V the authors say “We used a sample of 1 640 hot subdwarfs, including 142 pulsators, to check the distribution of pulsators across the Galactic populations”, but then only the distribution of pulsating subdwarfs is discussed. What about non-pulsating subdwarfs?

The above comments do not in any way diminish the high quality of the dissertation, which presents a comprehensive study of pulsating hot subdwarfs based on TESS data. Sumanta Kumar Sahoo has demonstrated his ability to process and analyse large datasets with various techniques, as well as to interpret the results and draw accurate conclusions. The publications that constitute the thesis have already been recognized by the astronomical community, which is reflected in their citation count, while the fact that he is the first author on four of them proves his ability to independently carry out scientific research.

Summing up, I consider the doctoral thesis of Sumanta Kumar Sahoo to be a valuable contribution and to meet the criteria prescribed by the law for a doctoral dissertation. Therefore, I request that this dissertation be admitted to a public defense.

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