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Opinion on the thesis submitted for the "Doctor of the Academy" title called

"Origin of the chemical elements heavier than iron and of meteoritic stardust from asymptotic giant branch stars"

written by Maria Lugaro

The topic of this research

The question of how the elements in the periodic table formed has always fascinated humanity. This question was finally answered in the middle of the 20th century with the discovery of Technetium, which proved that elements found in Earth and across the Universe are formed in the core of stars. As such, the theory of stellar nucleosynthesis was proven and in the subsequent years and decades it became one of the most research topics in astronomy.

Elements heavier than iron form with the process called neutron-capture, which have two types: the slow neutron-capture which happens in AGB stars, and rapid neutron-capture that happens in explosive stellar environments. The thesis mainly focuses on understanding the slow neutron capture-process in AGB stars and how it affected the chemical composition of our Solar System, thus the work presented here covers a topic that has not been studied in Hungary before.

Scientific results presented in the thesis

Scientific results are presented in four thesis points. The first thesis point details the discovery of a new process called intermediate neutron-capture, which may help to explain the anomalous abundance of elements (Ba and Eu) in metal-poor halo stars that cannot be explained by the slow or the combination of slow and rapid neutron-capture process. In the second thesis point, the author explain her results related to the examination of SiC grains found in meteorites originated from C-rich AGB stars.

She successfully explained the origin of silicate grains depleted in ^{18}O as being formed in the envelope of massive AGB stars in the third thesis point. The fourth thesis point presents the decoupling of radioactive nuclei produced by the r- and s-procceses in the early Solar System, proving that the formation of our Solar System was affected by both core-collapse and Type Ia supernovae and the stellar winds of AGB stars.

I accept all the results discussed in these four thesis points as new scientific discoveries achieved by the author.

The structure of the thesis

The thesis is 142 pages long with acknowledgments and appendix. It is divided into six main sections: the first is an introduction, the second section details the employed methodology. The third section explains the science results related to neutron capture process in low metallicity AGB stars, the fourth section is about the origin of meteoritic stardust produced by AGB stars and the fifth section details the origin of short-lived radioactive nuclei and the chemical composition of our Solar System. The sixth section summarizes the thesis results.

All sections are very-well written, and all have the same subsection structure which make navigating the thesis very easy. The text clearly explains which section belongs to which refereed publication and what the contribution of the author had to these results. I find it especially appealing that the style of the thesis allows every astronomer to easily understand the science behind these results and I consider the thesis a must read for every student of astronomy who wish to pursue understanding the formation of chemical elements in the Universe. The figures are very informative, though sometimes a little bit small. Overall, I find that the thesis is extremely well structured and written.

Publications and science metric

A quick search on ADS reveals that she is the co-author of more than 140 refereed publications, which have received over 6000 citations as of writing this evaluation. More than 25 of those are first author papers. The thesis was written by using 12 refereed paper, 11 of those are first-authored, most of them are highly cited in the literature.

She also led the Lendület AGB Nuclei and Dust group starting in 2014, and since 2016 she is the leader of the ERC Consolidator Grant project called RADIOSTAR. Winning these most prestigious

grants requires the coordination of large number international collaborators showing her ability to lead a diverse research group from across multiple countries.

As the citation metric and her grants show, Maria Lugaro is one of the most accomplished astronomers not just in Hungary, but around the World in general. She is highly regarded in the community and her research represents the best one can accomplish in astronomy.

Questions

I have the following questions related to the thesis and its science results.

1. In the last decade multiple high-resolution spectroscopic surveys, such as APOGEE, GALAH and Gaia-ESO determined the chemical composition of hundreds of thousands of stars. Could you please give a short overview of how these large surveys contributed to understanding the slow neutron capture process in general?
2. What are the most important elements for understanding the slow and intermediate neutron capture process that do not have detailed abundances determined by these surveys (or by individual studies) and how could we get them using high resolution spectroscopy? What wavelength region should we observe and with what resolution and signal-to-noise to reliable measure the absorption lines of these elements?

Overview and final evaluation

Maria Lugaro is an internationally respected researcher who accomplished groundbreaking science results in the field of theoretical stellar nucleosynthesis and won some of the most prestigious grants available for scientists. The science results presented in the thesis are essential for understanding the process of slow neutron capture happening in AGB stars and the formation of our Solar System. Upon successful defense I recommend she receives the "Doctor of the Academy" title.

Szombathely, August 12, 2022

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