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Report on the doctoral thesis "Study of the diversity of Type Ia Supernova Progenitors", presented by Lilit V. Barkhudaryan (A.I. Alikhanyan National Science Laboratory, Yerevan Physics Institute) for acquiring the degree of candidate of physico-mathematical sciences in division 01.03.02 "Astrophysics, radio astronomy"

08/11/2023

The PhD thesis of Ms. Lilit V. Barkhudaryan is devoted to the investigation of the nature of SNe Ia progenitors and their spatial distribution in galaxies. Special attention was paid to approximately 1/3 SNe Ia with unusual properties, classified as 91T- and 91bg-type SNe, the first one being overluminous and the second one underluminous at the maximum of the B-band light curve (LC). This topic is undoubtedly important both for a better understanding of the physical mechanisms and the corresponding timescales leading to Type Ia SNe (in particular for distinguishing between different scenarios such as the single-degenerate and double-degenerate channel at the Chandrasekhar mass limit M_{Ch}, or the double-detonation scenario of a sub-M_{ch} white dwarf), and for developing a coherent picture on the spatial distribution and surface density of the various SNe Ia types as a function of the structural and evolutionary properties of the galaxies in which they occur (e.g., morphological type, bulge-to-total ratio, age and metallicity).

After a well-structured introduction didactically presenting the main scientific motivation for this project, the proposed mechanisms of SNe explosions and the nomenclature, Chapter 1 of the doctoral thesis investigates the vertical distribution of SNe in a sample of 100 high-inclination (≥85°) disc galaxies selected from SDSS DR12. To this end, the $sech^2$ and exponential scale lengths of the different SNe types are derived and their relation to the thin and thick disk is examined. For the first time, it is shown that the ratio of scale lengths to scale heights of the distribution of core-collapse (CC) SNe is consistent with the distribution of young (<100 Myr) stars and that CC SNe are about twice as concentrated on the disk plane as SNe Ia. Additionally, it is shown that the spatial distribution of SN Ia is consistent with that of old (up to several Gyr) stellar populations. These findings reflect the age-scale height relation and the age difference between CC and Type-Ia SNe progenitors. They have emerged from a careful sample selection and a meticulous data analysis, in which possible biases due to dust obscuration and redshift were evaluated and shown not to affect the main conclusions of this study.

Building on the methodology applied in Chapter 1 and motivated by the empirical finding that a) SNe Ia are more evenly distributed than CC SNe (Hakobyan et al. 2017) and b) the LCs of SN Ia correlate with the luminosity-weighted age of galaxies (Hakobyan, Barkhudaryan et al. 2020), in Chapter 2 Ms. Barkhudaryan extends the analysis to the investigation of the vertical height of SNe Ia subclasses 91T and 91bg separately. It turns out that SNe 91T are relatively young (a few 10^8 yr), while 91bg are significantly older (one to ten Gyr). Importantly, this study demonstrates for the first

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time that these two SNe Ia subclases have a different spatial distribution relative to the disk plane. Another notable finding is that LC decline rates (Δm_{15}) correlate with the disk height, which is consistent with model predictions of sub-M_{Ch} mass white dwarfs and the presence of a vertical stellar age gradient in galactic disks.

Following the study by Barkhudaryan et al. (2019), which found that SN type depends more on the age than on the mass or metallicity of an elliptical galaxy, with 91bg-like SNe being primarily associated with old UV-faint galaxy hosts, Chapter 3 improves on the previous work by including LCs for a larger and more representative sample (407 sources comprising normal SNe Ia as well as peculiar 91T, 91bg and 02cx Ia types) from the SDSS and other publicly available sources (e.g., Pan-STARRS and SkyMapper Souther Sky Survey). Interestingly, the LC decline rates, quantified by Δm_{15}, are shown to follow a bimodal distribution, with the 91T (91bg) SNe populating the slower (faster) LC decay brunch. Based on this large sample, it was also possible to corroborate previous evidence for a correlation between the LC decline rates of normal SNe Ia and the age of the host galaxy, with SNe Ia residing in bluer galaxies ('below' the Green Valley) being characterized by faster declining LCs and vice versa. As Ms. Barkhudaryan convincingly argues, the double-degenerate channel is consistent with the observational evidence for 91bg-like events, while the single-degenerate channel may be more appropriate for 91T-like SNe.

The fourth and final chapter of the doctoral thesis focuses on (104) elliptical galaxy hosts, which, as found previously, mostly host normal and 91bg-like SNe Ia. An important conclusion from this study is that the radial distribution of SNe Ia events is consistent with a de Vaucouleurs profile.

I consider that the doctoral thesis of Ms. Lilit V. Barkhudaryan meets the international standards for doctoral theses in Exact Sciences and the requirements for the degree of candidate of physico-mathematical sciences. It documents the candidate's ability toward analytical thinking and critical reflection as well as her expertise in the field of SNe and extragalactic astronomy. This doctoral thesis is the result of a detailed and careful analysis of the best available samples using state-of-the-art techniques and makes a significant contribution to our knowledge about SNe progenitors. This is also reflected in the publications in prestigious astrophysics journals that have resulted in the framework of Ms. Barkhudaryan's PhD research project, including her single-author article in MNRAS, 520, L21 (2023). The rich scientific output of this PhD project justifies the extension of this line of research by utilizing spatially resolved integral field spectroscopy data and advanced spectral synthesis techniques with the aim of further elucidating the connection between the different subclasses of SNe Ia and their galaxy hosts.

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