Institut d'astrophysique de Paris

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REPORT

on the Thesis: *"Study of supernovae and their host galaxy dynamical features"*

Presented by Arpine Karapetyan for the Degree of Candidate in Physical and Mathematical Sciences (equivalent to a Ph.D. degree) in the Specialty 01.03.02 – Astrophysics, Radio Astronomy

This thesis is dedicated to unravelling the connections between the dynamical features of host galaxies and the photometric properties of supernovae (SNe), with the aim of gaining insights into the nature of their progenitor stars. The spatial distribution of SNe within host galaxies plays a central role in this study, providing a valuable means to impose constraints on the features of SN progenitors. The research delves deeply into how spiral density waves and stellar bars influence the distribution of star formation in the context of SNe. To accomplish this goal, the study assesses the properties of stellar populations within host galaxies, while scrutinizing the spectral and photometric attributes of SNe. Particular emphasis is placed on the dynamical ages of these galaxies. Compared to similar studies, this thesis addresses several issues yet unexplored in SNe host galaxy research, conducting relevant investigations and provides original insights on SN progenitor systems.

Chapter one investigates the impact of bars and bulges on the radial distributions of different types of SNe within the stellar discs of host galaxies exhibiting diverse morphologies. The findings of this investigation provide strong confirmation that old bars/bulges in S0–S0/a galaxies play a significant role in shaping the radial distribution of Type Ia SNe. Additionally, the study sheds light on the significantly distinct radial distributions of core-collapse (CC) SNe in galaxies with and without bars. These differences are interpreted as due to substantial suppression of massive star formation within the radial range swept by strong bars, particularly in early-type spirals.

In the second chapter of the thesis, a comprehensive comparative study has been undertaken. It explores the locations and light-curve decline rates (Δm_{15}) of both normal and peculiar Type Ia (SNe Ia) within regions known as star formation deserts (SFDs) and in surrounding galactic discs. This analysis exploits the SFD phenomenon, which proves to be an invaluable means of differentiating a subpopulation of SN Ia progenitors with ages extending beyond several billion years.

The focus of the third chapter is the intriguing issue of how spiral density waves may impact the distribution of SNe. For CCSNe, a significant difference has been found when comparing their normalized radial distributions in long-armed grand-design versus non-grand-design hosts. Moreover, an intriguing pattern emerges for the surface density distribution of CCSNe. When it is normalized to corotation radii (R_C), the density distribution indicates a dip at corotation. These findings offer robust support for the hypothesis of large-scale shock induction by spiral density waves within grand-design galaxies. This phenomenon predicts higher star formation efficiency around the shock fronts while avoiding the corotation region.

Chapter four is dedicated to the exploration of SNIa progenitors through their spatial locations relative to spiral arms. This investigation uses original measurements of SNIa distances from nearby arms and their light-curve decline rates. For the first time, it is unveiled a significant correlation between the Δm_{15} values (a measure of the decline rate of the light curve) and the distances of SNe from the shock fronts of the spiral arms, which are assumed to be the corresponding progenitor birthplaces. The results of this chapter are interpreted within the frameworks of density wave theory. According to this theory, SN progenitors are postulated to have their origins around the shock fronts of spiral arms. Subsequently, they migrate across and away from the spiral pattern until their explosion, after a period depending on their lifetime and the time required to meet explosive conditions); here the rate of SN light-curve decline serves as an indicator of progenitor age. This process is explored alongside the framework of white dwarf star explosion models with mass smaller than the critical Chandrasekhar mass M_{ch} (sub-M_{ch} progenitors)

The "General Conclusions" section summarizes the obtained results.

A substantial part of the research conducted in this thesis is original work, providing new and interesting results. The author's publication record comprises four comprehensive papers that thoroughly present the findings of this dissertation, including a single-authored paper. These papers have been successfully published in high-ranking journal within the Astronomy and Astrophysics fields and constitute the four aforementioned chapters.

I found the manuscript rather well written, clearly presenting the adopted assumptions and methods. Still, I think that a few points deserve further work. a) a more moderate use of the many abbreviations, which make the reading difficult, b) a more thorough introduction to the physics of the studied objects (examples: what is a "core-collapse supernova, which core and why it collapses and how the collapse turns into explosion; what is a SNIa, why it explodes and why it takes so long to explode, as well as more physics on galactic physics), which make the life of the reader easier, c) there is no real quantitative comparison with other authors, e.g. if the obtained radial distributions differ from others and why, d) a clear presentation of the Phillips relation connecting Δm_{15} to the mass of Ni56 (making the connexion to explosion time more shaky) and, very importantly : e) after the Conslusions some « opening to the future » suggesting further work that would allow to go deeper into the studied topics or connect them more to the general field of supernova research.

My overall impression is that the presented work has important original aspects and some of its results constitute a valuable asset for supernova research. In my opinion, this thesis successfully meets the criteria for the award of a candidate's degree in physical and mathematical sciences (equivalent to a Ph.D. degree), specifically in the field of 01.03.02 – Astrophysics and Radio Astronomy. Its author, Arpine Karapetyan, certainly deserves this scientific degree.

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