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**Review of the doctoral dissertation by Mgr. Subhrata Dey, entitled
„Panchromatic Spectral Energy Distribution modelling of infrared bright galaxies”**

Mgr. Subhrata Dey's doctoral thesis concerns problems related to the study of infrared bright galaxies, by means of panchromatic modelling of their spectral energy distribution (SED). The infrared bright galaxies like Luminous and Ultra-Luminous Infrared Galaxies (U/LIRGs), are very important sources for studying galaxy formation and evolution. Simultaneous studies at multiple wavelengths, both photometric and spectroscopic, provide information on interplay between various physical processes that are important in different wavelength domains. The novelty of this dissertation is an attempt to understand the relationship between the results obtained from spectral energy distribution (SED) modeling using only the UV-IR domains and only the radio frequency (RF) domain separately, and those obtained by considering these two regimes simultaneously. Mgr. Subhrata Dey convincingly demonstrates that important results can be achieved by using this modern astrophysical approach. In this context it is worth to mention that the Square Kilometer Array (SKA) will provide enormous number of radio observation, which may be analyzed by method developed by mgr. Subhrata Dey. The PhD thesis of mgr. Dey is an extended compilation of two multi-author research papers, already published in the Astrophysical Journal with her as the primary author. This is not a simple “stapling” of the two articles but rather an edited book. Such an approach is used in different countries, particularly in the Netherlands, and requires the candidate to perform additional careful work.

The main dissertation (Chapters 5-7) is preceded by a general introduction, followed by a description of the data used in the thesis, as well as the methodology for radio-only SED modeling and the application of the CIGALE (Code Investigating GALaxy Emission) program for SED modeling across the entire spectral range: UV-IR-RF. In the several-page-long general introduction to the dissertation, she introduces the importance of multiwavelength observations of galaxies for unraveling their complexities and provides a brief yet comprehensive description of the different components and processes that manifest themselves at various wavelengths: X-rays, powered by active galactic nuclei (AGN) and X-

ray binaries; UV-NIR range, showcasing stellar populations and their history in galaxies; MIR-FIR domain, mostly dominated by radiation reprocessed by dust in different regions of galaxies; and the radio frequency range, mostly originating from star-forming regions, AGNs, and fast jets. Next, she explains the complications in interpreting the radio emission, which results from the superposition of thermal and non-thermal components. She emphasizes the necessity of using sophisticated models to disentangle these two components. Mgr. Dey describes also the current state of knowledge about galaxy formation and evolution in a concise, clear, and informative manner, underlying importance of U/LIRGs at larger redshifts. The chapter ends with a brief description of the thesis contents.

Next, Mgr. Dey introduces the data and methodology used for the SED modeling across different wavelength domains (Chapters 2-4). In addition to describing the archival data utilized in the thesis, she presents data obtained from their dedicated observations with the Giant Metrewave Radio Telescope (GMRT) for the investigated sample of LIRGs. For data reduction from both the GMRT and the archival VLA data, she employs the AIPS software, demonstrating a strong understanding of this complex tool for radio astronomy data reduction and analysis. Many observations from various instruments were collected to construct densely covered SEDs across different frequencies/wavelengths, which were used in RF/UV-IR domain modeling. In the following chapter, she describes her physically motivated approach to radio-only SED modeling. For this purpose, she developed a code based on the nested sampling algorithm (a modern package UltraNest). UltraNest is a Bayesian inference package that operates on the principle of the Monte Carlo technique. It is designed for high-dimensional parameter space exploration, providing robust and efficient sampling and evidence estimation. Finally, Mgr. Dey describes methodology of SED modelling in the whole spectral range with CIGALE code. By modeling the full SED (UV-optical-IR-RF), CIGALE helps determine the star formation history of galaxies, estimates stellar mass and the history of mass assembly, assesses the amount and properties of dust within galaxies, and helps isolate the impact of AGN on galaxy evolution. Mgr. Dey clearly describes the parameters of the CIGALE code and demonstrates a deep understanding of their limitations and uncertainties. This section of the PhD thesis showcases Mgr. Dey's comprehensive understanding of the challenges of using advanced SED modeling software. I consider this part of the dissertation to be well-written and important, as it presents in a simple way the methodology and tools used in the main sections of the PhD thesis.

Chapter 5 is one of the sections that contain the main results of the doctoral dissertation. It is devoted to SED modeling of 11 carefully selected LIRGs in the radio-only domain and in the UV-IR bands. In the second approach, the longest wavelength passbands are from AKARI and Herschel/PACS and SPIRE instruments, if available; however, a simplified non-thermal radio emission is also included, which allows for better estimation of the dust luminosity uncertainties. It is worth noting that detailed modeling of densely sampled radio SEDs with physically motivated processes is necessary to understand galaxies' emission and absorption processes. It is a relatively rare approach, and the inclusion of such modeling in the thesis provides very valuable results. On the other hand, UV-IR SED modeling allows for the understanding of different astrophysical processes such as star formation and evolution, chemical enrichment, processes in the interstellar medium, and activity in their nuclei. As stated in the dissertation, *“One of the primary goals of this work is to compare the astrophysical properties resulting from SED modeling at radio-only and FUV to radio bands.”* However, in my opinion, the results are rather supplementary and allow for the full characterization of the evolutionary stage of a galaxy, even though some predictions from both approaches can be compared. Nonetheless, the presented fits are impressive and show

that it is possible to perform modeling of SEDs in different wavelength regimes with a physically motivated approach. One general concern I have is that the SED fitting utilizes a wide grid of free parameters to search for the best fit, sometimes with certain sophisticated modifications. Unfortunately, the number of free parameters is very often larger than the number of observational data points. However, despite my reservations about such an approach, I believe it still provides reasonable results. Mgr. Dey summarizes the obtained results and compares their predictions with those obtained by different methods/researchers. In general, they are consistent, showing that the selected sample “*belongs to a homogeneous population of LIRGs with respect to their astrophysical properties.*” This applies to q_{IR} and AGN fraction, as well as many other parameters. It is worth mentioning a good correspondence found between the total and nonthermal radio SFRs with infrared SFRs averaged over the last 10 Myr from the CIGALE analysis, which indicates that the corresponding luminosities are good indicators of recent star formation in LIRGs.

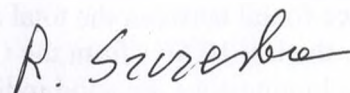
Chapter 6 extends the approach developed in Chapter 5 (i.e., simultaneous modeling of UV–IR–RF SEDs using CIGALE and densely sampled radio SEDs) to a sample of 14 ULIRGs. To achieve this goal, densely sampled observations at both the radio and UV–IR wavelengths were collected for a carefully selected sample of ULIRGs. For SED modeling in the UV-IR-radio range, an updated version of the CIGALE code was used, while maintaining consistency with the previous modeling of LIRGs. For radio-only SED modeling, again the physically motivated models have been used. A careful analysis of the obtained best-fit models was performed for the entire sample of ULIRGs. Once again, the best models in both wavelength regimes are compelling and very impressive. In general, the galactic parameters obtained from the modeling are consistent with those of other ULIRGs, except for a sophisticated decomposition of their radio emission. Additionally, incorporating radio data into the CIGALE modeling has increased the accuracy of the dust luminosity and SFR determination.

I am confused, however, by the discussion in the last para of Sect. 6.6.1. What has been used to compute the q_{IR} according to Eq. 6.1: the observed fluxes at 60, 100 μm and 1.4 GHz, or the fluxes from the best fits? If the fits shown in Fig 6.2 are used, then it appears that in many cases, the fluxes at 60 and 100 μm are underestimated, so q_{IR} will be too small. This may explain the observed discrepancy. The fits for LIRGs from Chapter 5 seem to be much better at 60 and 100 μm , so no discrepancy is seen there. BTW: regarding Fig 6.3b, the statement “*The values of our sample of galaxies lie around a rather uniform value of ~ 2.58 ,...*” does not seem to be true.

In the following subsections, a comprehensive analysis of the obtained results and their interpretation is presented. This applies to the inferred complex structure of the radio spectra; the emission measures, which are consistent with those determined for other similar class galaxies; the thermal fraction, which is determined from the decomposition of the radio SED into thermal and nonthermal components; the starburst timescales in the investigated sample of U/LIRGs; the calibration of the radio component SFRs and the reasons for the observed relations with the SFR from the CIGALE modeling; and the absence of significant correlations between the nonthermal radio component and some properties of the modeled sample of U/LIRGs. Finally, in Chapter 7, Mgr. Dey summarizes the most important results of her dissertation and interestingly discusses future prospects based on past her experience and achievements.

In conclusion, I think that Mgr. Dey's doctoral dissertation is valuable and meets the formal requirements expected of doctoral dissertations. The candidate has demonstrated the ability to conduct scientific research effectively and possesses the necessary knowledge for the accurate interpretation of the obtained results. This leads me to recommend the admission of Subhrata Dey to the subsequent stages of the process, including the public defense of her doctoral dissertation.

Ryszard Szczerba

A handwritten signature in black ink, reading "R. Szczerba". The signature is written in a cursive style with a large, stylized 'R' and a long, sweeping underline.