English version

From the beginning of the 20th century, the study of galaxies' properties has become an important matter among astronomers, and uncovering their formation and evolution is considered one of the greatest challenges in modern astronomy. It is known that galaxies may have very different properties, starting from morphology (e.g., spiral, elliptical, irregular) to the dust or gas content, the mass of the stellar component, the rate at which stars are formed, and so on. For this reason, it is crucial to fully understand the processes that lead to the observed galaxy emission by estimating and analyzing their main physical parameters. It is even more important nowadays, with new upcoming large galaxy surveys, which are constantly expanding in the number of observations, but only sometimes gather the information necessary to constrain the star formation activity straightforwardly. The goal of my scientific project is to uncover, with a multi-wavelength approach, the physical properties of galaxies, especially their star formation activity, and test the reliability of their estimation with Spectral Energy Distribution (SED) fitting methods. This work mainly focuses on the ultraviolet (UV)-infrared (IR) spectrum, as it was widely demonstrated to trace the formation of young stars, and on the X-ray regime, which presents promising results in constraining physical parameters such as star formation rate (SFR) and stellar mass (M_{star}).

The first part of this work focuses on how the upcoming optical Legacy Survey of Space and Time (LSST) data from the Vera C.~Rubin Observatory can be employed to constrain the physical properties of normal star-forming galaxies. It presents a catalogue of simulated LSST observations and uncertainties of ~ 50\,000 real galaxies, within the redshift range $0<z<2.5$, from COSMOS and ELAIS-N1 fields of the \textit{Herschel Extragalactic Legacy Project} (HELP) survey. We chose HELP as a reference survey because, at the moment, it provides the biggest dataset with the best mid-infrared (MIR) and far-infrared (FIR) data available, necessary for the estimation of the dust-related physical properties to compare with the LSST estimates. The actual estimation was performed by fitting the SED of galaxies using the Code Investigating GALaxy Emission (CIGALE).
Comparing the properties, such as the SFR, the M_{star}, and the dust luminosity (L_{dust}), obtained from the fit of the observed multi-wavelength photometry (from the UV to the FIR) to those obtained from the simulated LSST optical measurements alone.

This work shows a clear difference for the dust-related parameters (SFR, dust luminosity, dust mass), highly dependent on redshift. The stellar masses estimated based on the LSST measurements are instead in good agreement with the full UV to far-IR estimates. To correct the difference, we find it necessary to have a prior knowledge of the sample, such as employing auxiliary rest-frame MIR observations, simulated UV observations, or the far-UV attenuation (A_{FUV})- M_{star} relation.

The second part of this work focuses on the properties of X-ray binaries (XRBs), how they affect the total X-ray luminosity of a galaxy, and what kind of correlation exists between their integrated X-ray luminosity and galaxies' physical properties. In fact, it is well known that the XRBs emission traces the galaxy's stellar population and was found to scale with the SFR and the M_{star} of the host galaxy.

First, we study the properties of the population of low-mass X-ray binaries (LMXBs) hosted by globular clusters (GCs) in the Fornax galaxy cluster. The data used are a combination of \textit{VLT Survey Telescope} (VST) and \textit{Chandra} observations. We found that, as was already observed for the innermost regions of the galaxies, LMXBs tend to form in red and bright GCs, as these properties are, respectively, a proxy of the total number of stars and of the compactness of the globular cluster. These characteristics are essential for the formation of LMXBs in such environments. However, we find that the likelihood of a red GC hosting an LMXB decreases with galactocentric distance. Still, it remains approximately constant for the blue GC population. Regarding the X-ray properties of the hosted LMXBs (GC-LMXBs), we find a difference in the X-ray luminosity function (XLF) between the intra-cluster and host-galaxy samples. We further investigated the spectral properties of the GC-LMXBs, and we found a puzzling difference in the hardness ratio of the two populations, where the intra-cluster GC-LMXBs appear to have harder spectra than the host-galaxy objects. The same trend was found between the blue and red samples of GC-LMXBs. This trend was never observed before. Furthermore, we find that the total X-ray luminosity of the galaxies is dominated by the field LMXBs, with little contribution from the GC-LMXBs. This suggests that the well-known scatter of the Lx-SFR scaling relation at low SFR is mainly driven by field LMXBs.

Second, this work presents measurements of the relation between X-ray luminosity and star formation activity for a sample of normal galaxies spanning the redshift

range between 0 and 0.25. We use data acquired by the next-gen X-ray observatory SRG/eROSITA, for the Performance-and-Verification-Phase program named the eROSITA Final Equatorial Depth Survey (eFEDS).
Making use of a wide range of ancillary data, spanning from the UV to MIR, we estimate the SFR and M_{star} of 888 galaxies, using the CIGALE code. In order to study sources with negligible X-ray component attributable to Active galactic nuclei (AGN), we perform the identification of AGN systems making use of the observed fluxes in the X-ray, optical, and MIR range, and using the results from the SED fitting. We validate the results from the SED fitting and the AGN identification using FIR data from HELP and spectral lines from MPA/JHU catalog based on the \textit{Sloan Digital Sky Survey} DR7 release. To isolate the contribution of High mass X-ray binaries (HMXBs) and LMXBs, that scales with the SFR and stellar mass, respectively, we subtract the contribution of hot gas, coronally active binaries, and cataclysmic variables to the total X-ray emission. We divide our sample into star-forming (SFGs) and quiescent, according to their position on the main sequence relation.
As already observed in previous works, we find a linear correlation between the X-ray luminosity and the SFR for our sample of SFGs. However, we find this relation to be strongly biased by the completeness limit of the eFEDS survey. Correcting for completeness, we find the calibrated Lx-SFR to be consistent with the literature. The X-ray emission of normal galaxies is not only dominated by the contribution of HMXBs but also by the contribution of LMXBs, which is expected to scale with the M_{star}. It was shown that the ratio of HMXB-to-LMXB emission is sensitive to the specific SFR (sSFR), defined as SFR/M_{star} . To consider this, we quantify the scaling factors \alpha = $L_{x,LMXB}$/M_{star} and \beta = $L_{x,HMXB}$/SFR. Even correcting for completeness, we find a consistently higher contribution of LMXBs than observed in previous works. We conclude that, due to completeness issues, without performing a stacking process it is not possible to employ eFEDS data to study the redshift evolution of the LMXBs and HMXBs contributions to the scaling relation. Nevertheless, we find our single sources to largely scatter from the expected Lx/SFR vs sSFR relation at high redshift. We discuss the dependence of the scatter on size, metallicity or globular cluster content of the galaxy.