UNIVERSITEIT VAN AMSTERDAM

The Properties and Impact of Stars Stripped in Binaries
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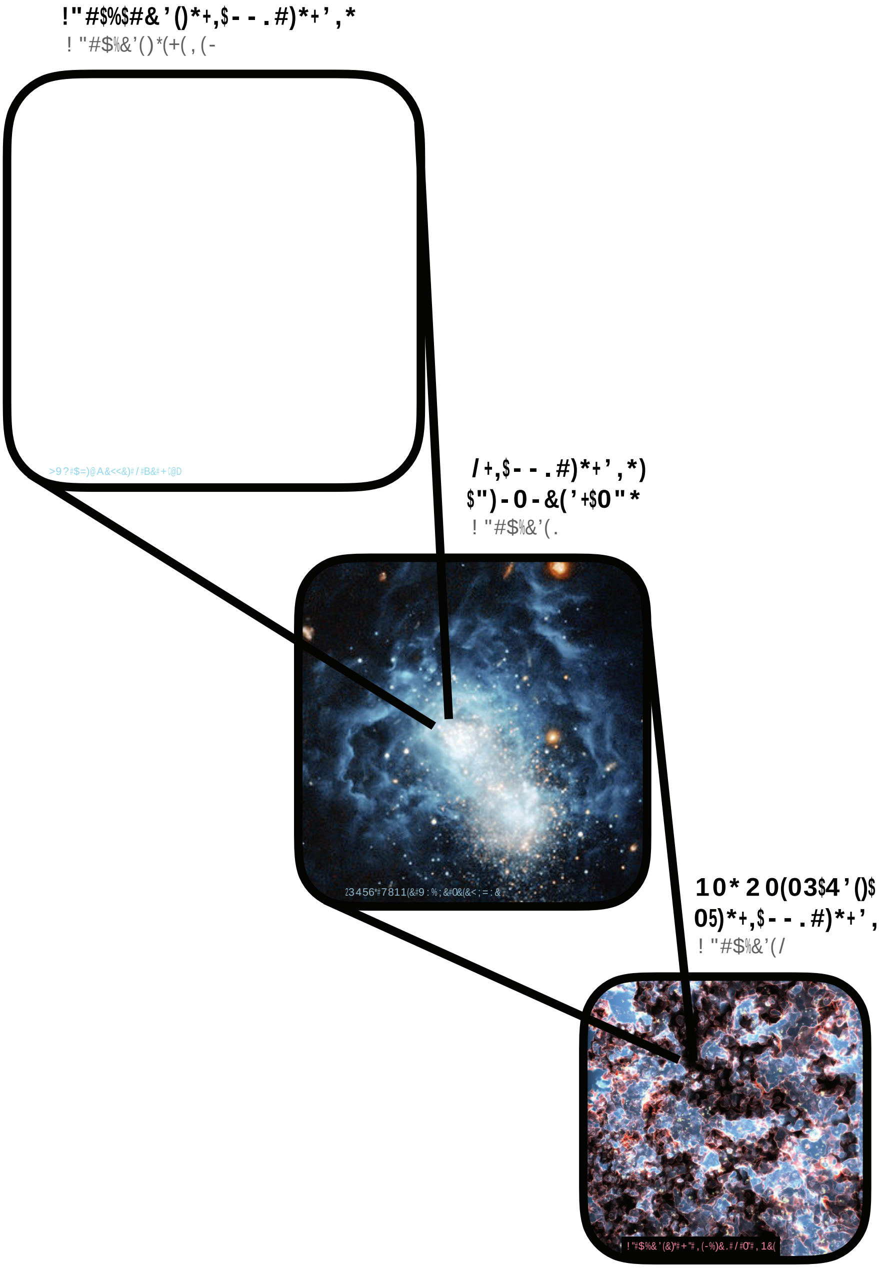

Figure 1.3: A graphical summary and outline of this thesis. Image credits: ESO, Kornmesser & de Mink (artist's impression of massive binary during mass-transfer phase), Hubble Space Telescope (image of the low-metallicity galaxy IZw18), and Kaehler, Alvarez & Abel (visualization of hydrogen reionization from simulations published in Alvarez et al. 2009).

stripped stars have through their ionizing radiation, for example, during the reionization of the Universe (Chapter 6).

Our focus is, in particular, on the ionizing emission from stripped stars. Ionizing radiation is important for a variety of astrophysical research fields. Ionizing radiation creates H II regions around individual stars that expand into the interstellar medium. The bulk of ionizing photons produced by hot stars create giant H II regions and power a diffuse field of extreme UV radiation in galaxies as a whole. Such photons can, for example, dissociate molecules and charge dust particles. The ionized gas in the H II regions shines, sometimes very brightly (see e.g., the Green Pea galaxies, Cardamone et al. 2009), in certain emission lines of ionized elements, which provides information about the the local conditions as well as the ionizing sources. In a cosmological perspective, ionizing radiation caused cosmic reionization. The amount of ionizing photons that stellar populations produced is a crucial parameter for understanding the sources of ionizing radiation during this cosmic phase change.

The chapters in this thesis start with the physics of individual stars and gradually zoom out to end with a discussion of the possible implications on cosmological scales, as graphically depicted in Fig. 1.3. This thesis consists of the following chapters:

Chapter 2 We test the effect of metallicity and wind mass-loss on the structure and evolution of stripped stars. We evaluate how large their effects are on spectral properties and the emission rate of ionizing photons. Comparing the spectral energy distribution of a stripped star with possible companions, we find that stripped stars can easily be hidden by a bright companion star, which likely is the explanation to why they are rarely discovered.

Chapter 3 We extend our modeling efforts and compute large grids of binary evolutionary models and spectral models that are custom-made for stripped stars. We find that the spectra form a smooth sequence that links subdwarf type spectra with WR type spectra as the stellar mass increases. We then discuss different promising techniques to find and identify stripped stars by quantifying the most important biases. The large model grids allow to estimate which combinations of stripped stars and companions that are detectable and which biases to expect.

Chapter 4 The recently discovered WN3/O3 stars are isolated from other WR stars and show spectral features that are characteristic to stars with lower wind mass-loss than expected for WR stars. Since stripped stars are created with a delay, the WR stars originating from massive stars are expected to already have exploded and stripped stars are created without WR stars of the same star cluster being around. Stripped stars are also expected to have lower wind mass-loss than WR stars. We, therefore, discuss the possibility that the WN3/O3 stars are the long-sought products of envelope-stripping in binaries.

Chapter 5 We quantify the role of stripped stars in the ionizing emission from entire stellar populations by creating a spectral synthesis code for stripped stars that uses our spectral model grids presented in Chapter 3. We elaborate on the role of stripped stars in already observed samples of galaxies and what their effect is on measures for ionizing emission and common star-formation rate indicators. We discuss the hardness of the ionizing spectrum and how that can affect nebular emission. We make our models available via the online interface of the spectral synthesis code Starburst99 (Leitherer et al. 1999, 2010).

Chapter 6 We consider the effect of the ionizing radiation from stripped stars on cosmic evolution by estimating their impact on the Epoch of Reionization. We also discuss the effect of stripped stars on a few observable characteristics of the early Universe.

The final chapter of this thesis (**Chapter 7**) consists of a short outlook that shows a direction of research this thesis has built a base for. We show that one of the techniques presented in Chapter 3 has already helped to identify a large sample of stripped star candidates in the Large Magellanic Cloud using archival data. Are these indeed the stripped stars that have been missing and is the paradox resolved? The data is promising, but to find an answer to this question we still need careful consideration and follow-up observations. We hope that the theoretical models and methods presented in this work will continue to be of use to interpret and understand observations of these stripped stars and their implications.