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THE EFFECTS OF BINARIES ON POPULATION STUDIES

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RESUMEN

Realizamos una revisión del trabajo que se ha venido realizando en Bruselas desde 1997 sobre varios aspectos de los estudios de poblaciones y los efectos en sistemas binarios; poblaciones estelares y ritmo de explosiones de supernovas en regiones donde la formación estelar ocurre de una manera continuada y donde ocurre en brotes, evolución espectral esperada, evolución química de galaxias, etc.

ABSTRACT

We give an overview of the work that has been done in Brussels since 1997 on various aspects of population studies and the effects of binaries: stellar populations and supernova rates in regions where star formation is continuous and in starbursts, the expected spectral evolution of starburst regions, the chemical evolution of galaxies

Key Words: **BINARIES: GENERAL**

1. INTRODUCTION

The evolution of close binaries has been one of the main research topics the last 30 years of the astrophysics group of the Vrije Universiteit Brussels. About 7 years ago we started an overall study on the effects of binaries on simulations of the temporal evolution of stellar populations (number synthesis and spectral synthesis) in regions where star formation is assumed to be continuous and in starbursts, and on the Galactic chemical evolution.

The present paper gives a short overview. Due to the limited space, we decided to discuss mainly the work done in Brussels. Notice however that many research groups have studied the effects of binaries on stellar populations. But as far as the chemical evolution is concerned, we think we are the first to consider the effects of binaries in some detail.

2. THE FORMATION OF HIGH MASS BLACK HOLES AND THE EFFECT OF WR-LIKE STELLAR WIND MASS LOSS ON THE EVOLUTION OF MASSIVE STARS

Explaining the existence of massive black holes (BHs, possibly with masses 10 $M_\odot$ up to 20 $M_\odot$ in the Galaxy and up to 40 $M_\odot$ in small metallicity regions) as end products of massive star evolution is inseparable from a discussion on the stellar wind (SW) mass loss during core helium burning (CHeB) of a massive star (the WR phase). Our preferred formalism that we use already since 1998, has been discussed in detail in Vanbeveren et al. (1998, a,b,c). It predicted rates which were a factor 2-4 smaller than formalisms used by most other stellar evolution groups and at that time it was therefore considered as revolutionary (discussions with referees were tough sometimes). However, there is growing evidence that indeed the WR rates are much lower and most evolutionary groups have since recently switched to formalisms which predict rates similar to those predicted by our formalism (see also Van Bever and Vanbeveren, 2003).

3. THE EFFECT OF ROTATION ON STELLAR EVOLUTION

The effects of rotation on massive star evolution has been studied by the Geneva group (e.g. Meynet and Maeder, 2003, and references therein). Vanbeveren et al. (1998a) investigated the probable distribution of rotational velocities of O-type stars and of early B-type stars. Both distributions illustrate that a significant fraction of the stars (70%-80%) has a very moderate rotational velocity with an average around 100 km/s. Both have a tail extending towards very large values (which affects significantly the statistical mean of the distribution) and this illustrates that investigating the effect of rotation on stellar populations by using evolutionary calculations with an average initial rotational velocity which recovers the observed statistical mean may be wrong. In any case, by inspecting the evolutionary results of the Geneva group, we conclude that for the majority of massive stars (may be up to 70-80%) the effects of rotation are moderate and at most similar to the effects of moderate convective core overshooting as it was implemented by Schaller et al. (1992).

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4. BINARIES AND STELLAR POPULATIONS

De Donder et al. (1997) and Vanbeveren et al. (1997, 1998a) studied the theoretically predicted WR and O-type star population (including those with a compact companion) using massive star evolutionary computations which accounted for recent stellar wind mass loss rate formalisms (as stated in section 1, sometimes considered as revolutionary at that time). These evolutionary calculations were discussed at length in Vanbeveren et al. (1998b, c).

The temporal variation of star populations in starbursts and their spectral evolution (UV and optical) were investigated by Van Bever and Vanbeveren (1998, 2003), Van Bever et al. (1999), Belkus et al. (2003). In particular, the population of high mass X-ray binaries and young supernova remnants in starbursts (and the expected hard X-radiation) was studied by Van Bever and Vanbeveren (2000) and updated recently (Van Bever, 2003, Ph.D. Thesis

The effects of binaries on the chemical (-elements due to SN and r-process elements due to SN and due to merging compact binaries) evolution of galaxies and on the temporal evolution of the SN rates in the Solar Neighbourhood (II's, Ibc's and Ia's) has been published in De Donder and Vanbeveren (2002, 2003a, b, c). We combine a population number synthesis code of binaries including the possible progenitors of SN Ias for which we consider the single degenerate (SD) and the double degenerate (DD) scenario, a star formation model, a galactic evolutionary model and stellar ejecta of single stars and binaries as function of metallicity. We conclude that as far as the stellar G-dwarf distribution as function of metallicity and the SN Ia rates are concerned, a model where the SD and DD scenario act together gives the best correspondence. The number ratio II/Ibc obviously depends on the overall binary frequency. The observed difference between the ratio in early type spirals and in late type spirals may indicate that both have a different (massive) binary population (De Donder and Vanbeveren, 1998).

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