Physics MASTER's, Université de Strasbourg
Subject: Astrophysics / Parcours : Astrophysique

RESEARCH PROJECTS 2017-2018

A Master's level research assistantship is available at the Observatoire astronomique de Strasbourg, France, with a start date of *1 March 2018* or later. The candidate should be enlisted in a Master's programme in Physics or related field at his or her home Institution.

Duration of the assistantship : 4 months (extendable to 5)* starting 1 March, 2018, or a date reached by mutual agreement.

Project supervisors

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Research Assistantship

Title: **Embedded binary stars & the formation of solar-mass black holes**

Address for correspondence (if different from the above):

Application procedure (if specific): send a letter of motivation and short CV to christian.boily@astro.unistra.fr .

Can this project be extended to 5 months* duration rather than the standard 4? **Yes**

Might the project be converted to a PhD fellowship? **Yes** (pending funds)

Can the student expect any financial support ? **Yes**

Details if yes : Allocation of the standard stipend to cover for local expenses.

Please use the second page of this form to provide details on the project.

* All Master's projects are evaluated in mid-June for students registered at the Université de Strasbourg regardless of the total duration of the assistantship.

Research Assistantship at the Observatoire astronomique de Strasbourg 2017

Embedded binary stars & the formation of solar-mass black holes

Scientific context

Stars form in binary- or multiple units at all epochs in a dynamical Universe. High-resolution observations of star-forming regions reveal complexes of stars and gas, with a wide range in mass and size, of filamentary- or irregular, clumpy geometry. When a binary star forms, it will become circular and stable after several orbits, and remain so until the evolution of the stars drives the binary toward a new configuration or dissolution. When the surroundings of a young binary systems are factored in, a stable configuration may never be achieved, and the binary either spiral inwards and merges, or it dissolves, on a dynamical timescale. The merger event resulting in more massive stars may tip the statistics of solar-mass black hole formation, and, indirectly, the detection of gravitational waves.

Aims of the project, previous work

Part I. A procedure developed to create synthetic, self-coherent complex distributions of stars will be used to surround binary stars with a realistic external gravitational potential arising from the surrounding stars[1]. The statistics of torques acting on the binary will be obtained with the objective to compute the time-evolution of the binary from a perturbation Hamiltonian. A characteristic timescale for the evolution of the orbital parameters will be sought with respect to the binary's initial properties (separation a, orbital period p). The aim is to compare this timescale with the typical orbital period in star forming regions, to contrast the binary's evolution with that driven by other mechanisms, such as two-body heating (fly-bys), and stellar evolution timescales (of massive stars).

Part II. A second aspect that will be explored is the coupling of the binary to a realistic distribution of gas obtained from numerical hydrodynamics. To get some orientation into the problem, the theory of polarisation of the gas by the binary will be reviewed analytically, using the *dynamical friction* description of the back-reaction of the gas on the binary[2] . Integration of the differential equations will allow to predict the relevant timescale for significant evolution of the binary when embedded in gas of arbitrary but realistic profiling (filaments, knots, ..). This timescale will be compared with the simpler situation with stars alone (part I above). Since massive stars are often found in binaries of near-unity mass ratios, the project will focus on determining the configurations that likely would drive the merger of two massive stars, to form a even more massive object. We will explore a range of stellar parameters, but put more emphasis on ≈ 50 Solar-mass WR stars. The merger of two WR stars would yield the formation of a stellar-mass black hole.

To study the impact of the surrounding gas on the evolution of the star forming region, the AMUSE package[3] will be used to determine whether the interstellar gas *within the formation volume* may yet prove enough to induce evolution in the binary stars. Reaching this stage of advancement would be an excellent way to carry the project over to a PhD.

References

[1] J. Dorval, C.M. Boily, E. Moraux et al. 2016, *The path to equilibrium of merger-driven star cluster formation,* MNRAS 459, 1213

[2] See e.g. F. J. S´anchez-Salcedo & Raul O. Chametla 2014, *Binaries traveling through a gaseous medium*, ApJ 794, 167 ; C. Korntreff et al. 2012, *Towards the field binary population: influence of orbital decay on close binaries*, A & A 543, 126.

[3] Link to the AMUSE platform for stellar dynamics modelling : http://amusecode.org