
PhD Project

Title: *Stars and Galaxies with ESO/VLT/Xshooter : joint optical and near-IR spectroscopic studies of stars and stellar populations.*

Supervision: Pr. Ariane Lançon, Strasbourg Observatory, France.

Collaborative context: This PhD will take place within the international XSL collaboration (PI S. Trager; collaborators in the Netherlands, Spain, France, Germany, Belgium, the USA). A strong and regular interaction is expected with the PI group in Groningen, NL (S. Trager, R. Peletier, Y. Chen), with specialists of stellar spectral synthesis (P. Hauschildt, Hamburg, D, and other groups), and with members of the collaboration interested in the spectral studies of star clusters and galaxies (R. Peletier, S. Trager, J. Walcher, J. Falcon-Barroso and others). An official "cotutelle" can be set up with one of the collaborators.

Starting date: October 2011.

Financial support: A 3-year fellowship is being requested from the Doctoral School (Ecole Doctorale Sciences de la Terre, de l'Univers et de l'Environnement – Strasbourg University). The CVs and academic records of candidates play a significant rôle in determining which PhD proposals are funded, although other elements enter the equation.

Candidates are requested to contact A. Lançon as soon as possible. Decisions are expected between May and July 2011.

Contact: `ariane.lancon@astro.unistra.fr`

Our understanding of the star formation history of the universe, and of directly related questions such as the formation of galaxies or the chemical evolution of matter, are based on our interpretation of the spectra of stars and stellar populations. I refer to this field of research as "Population Synthesis", and when using this term I include the two main subfields : the simulation of the emission of stellar populations, and the inverse problem, i.e. the determination of star formation histories and chemical evolution histories from observations of galaxies.

Near-IR light is much less sensitive to extinction than optical light, and carries information about stellar subpopulations that contribute little to the emission at shorter wavelengths : the cool and luminous stars of the red supergiant, giant and asymptotic giant branches. Asymptotic giant branch stars are thought to be responsible for the very red colours of galaxies at large redshifts (redshifts at which galaxies were not much older than 1 Gyr). Around $1\mu\text{m}$, it has recently been claimed that galaxy spectra even show signatures of cool stars on the lower main sequence, although this is still very much a matter of debate. The near-IR part of the spectrum clearly is complementary to optical/UV data in our studies of galaxies.

Despite decades of efforts since the birth of near-IR astronomy in the 1970s, it remains a fact that this part of the spectrum is difficult to exploit. Most studies have used observations of small

spectral segments in one or two of the near-IR spectral windows. Rare studies that attempt to analyse optical and near-IR spectra jointly show that results obtained from one or the other end of the data range do not agree very well (see Lançon et al., 2008, A&A, 486, 165 for an example based on star clusters in the starburst galaxy M82).

This PhD project aims at identifying and removing some of the main sources of these discrepancies. The problem the student will tackle first is a very fundamental one : our understanding of stellar spectra across the optical and near-IR spectral range.

Population synthesis relies on libraries of stellar spectra. Two options exist: one may use theoretical spectra or empirical ones. Theoretical spectra can be computed for any combination of fundamental properties (gravity, effective temperature, abundance pattern), but... they are not very reliable for the coolest stars (see Lançon et al., 2007, A&A 468, 205). Empirical spectra are obviously closer to nature, but of course their usage is not possible without some confidence in the theoretical models, since models are needed to assigne fundamental parameters to the stars observed. Thus, in any case, the match between observations and simulations of stellar spectra accross the whole optical + near-IR wavelength range needs to be assessed properly, and improved if necessary.

In practice, the student will work with the Xshooter Spectral Library (XSL) observations, obtained over the last 1.5 years by a collaboration led by Scott Trager (of which A.L. has been a member from the start). 236 spectra have been obtained already, and a Large Programme will be submitted within the coming year to extend this collection to about 600 stars, the number needed for full scale population synthesis. The student will focus on the ~ 130 cool stars present in the current library, and his/her first aim will be to assess these data and provide a means of inserting them in a population synthesis code. Steps include the classification of the spectra on an empirical basis, and the determination of fundamental parameters based on the comparison with models (available Phoenix models by P. Hauschildt and collaborators, or other models for cool stars to be requested from other teams).

Once a first generation of population synthesis models based on XSL will have been computed, the student will be able to exploit it to tackle one of many questions about stellar populations, based for instance on existing Xshooter archive data that will become public within the next year. Questions of particular interest to A. Lançon include the nature of massive star clusters: can their spectra be explained with single stellar populations, or are more complex histories required? It would also be interesting to reassess the question of the contribution of low mass stars to the near-IR light (which has implications in terms of the stellar mass function of galaxies). Population synthesis predictions based on XSL can also be applied to archive data from large all sky surveys and will be important for the analysis of data from future generations of telescopes (such as the James Webb Space Telescope), that will observe at near-IR wavelengths.

Important note: Applicants should have a profound interest in stellar physics and in the evolution of galaxies. They should be at ease with computers (unix/linux; no fear to learn new software or programming languages). They should be able to communicate well in the English language. Letters of reference (or names of referees) will be appreciated.