Thesis subject

Name of the laboratory: LAM (Laboratoire d'Astrophysique de Marseille)

Thesis advisor: EPINAT Benoît
Email and address: benoit.epinat@lam.fr, 38 rue F. Joliot-Curie, 13388 Marseille cedex 13
Tel: +33 (0)4 95 04 41 83

Co-advisor: P. Amram / philippe.amram@lam.fr

Subject's title: Impact of kinematics on star-formation in external galaxies

Executive summary:

Giant molecular clouds and HII regions are the fundamental scales to study how galaxies convert gas into stars as a function of dynamical processes and environmental variation within and between galaxies. The subkpc-scale allows to study the links between star formation and internal and environmental dynamical processes driving evolution through gravitation, velocity shear, disc structure, instabilities and turbulence mechanisms. The goal of this thesis is to study how galaxy dynamics acts on star formation processes, in combining multiwavelength and kinematical data of nearby galaxies, the only ones for which the spatial resolution is high enough.

Subject description:

Star-formation results from the gravitational collapse of gas clouds. The cold gas collapses into molecular gas, which in turn collapses to form star clusters. Once young and massive stars are formed, they ionised the gas around them. The star formation rate in a galaxy mainly depends on the gas density and is strongly impacted by the environment. However, star formation processes are dynamical, and depend on the gas motion from the molecular clouds up to the galaxy scales. In order to understand star formation processes, the kinematics of gas is requested: at large scale, velocity shear due to differential rotation may oppose to gravitation and impact the critical density necessary for the collapse; at small-scale, turbulence is preventing the collapse. Studies of the link between kinematics and star-formation are today limited due to the need for (i) the spatial distribution of gas, using e.g. molecular or neutral gas estimators, (ii) spatially resolved star-formation estimates which requires a large multi-wavelength dataset, and (iii) high resolution 2D kinematics information at both small and large scale, which is usually obtained from either neutral, molecular or ionised gas. In addition, while the Kennicutt-Schmidt law, an empirical relation between gas surface density and star-formation surface density at galaxy scales has been observed for a long time (e.g. Kennicutt 1998), such a relation at star-forming clouds scales have not yet been established on representative samples of galaxies.

The thesis will consist in analyzing the Herschel Reference Survey (HRS) for which ionised gas kinematics and multi-wavelength data are available (Gomez-Lopez et al. 2019). Molecular and neutral gas kinematics are also available for a subset of the sample. In order to get a higher resolution view of the star formation processes and to understand better the origin of the turbulence observed in unresolved HII regions, the sample will be complemented with more nearby galaxies observed with the SITELLE Fourier Transform Spectrometer (FTS) at the CFHT in the frame of the SIGNALS large program (Rousseau-Nepton et al. 2019). The latter observations have a resolution better than 50 pc, which is mandatory to resolve HII regions in external galaxies. They also provide key line diagnostics to study both kinematics and ionisation conditions in these regions. This will allow the student (i) to understand whether the velocity dispersion observed in these datasets is due to collapse, feedback or thermal turbulence, (ii) to study the impact of both large and small scale kinematics on the local Kennicutt-Schmidt law and (iii) to better understand the impact of spatial resolution on these analyses. The student will also have a unique opportunity to pursue kinematics studies of the HRS sample, in particular to understand how the angular momentum is distributed in these galaxies. In addition, the HRS sample contains galaxies in both field, groups and clusters, which will make this study unique to investigate the impact of environment on both star formation processes and kinematics.

Bibliography:

Kennicutt-Schmidt, 1998, ApJ, 498, 541
Gomez-Lopez et al., 2019, A&A, 631, 71
Rousseau-Nepton et al., 2019, MNRAS, 489, 5530