Thesis subject

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

Thesis advisor: Guilaine Lagache
Email and address: guilaine.lagache@lam.fr ; LAM, Pôle de l'Étoile Site de Château-Gombert 38, rue Frédéric Joliot-Curie 13388 Marseille cedex 13 FRANCE
Tel: +33 6 50 77 35 45

Subject's title: Mapping the dusty star formation at high redshift with the NIKA2 Cosmological Legacy Survey and NOEMA and ALMA follow-up observations

Subject description:
Among the potentially most important results of cosmology over the last 20 years has been the discovery of the importance of dust obscured star formation. While dusty galaxies are rare in the local Universe (~1%), they are 10 to 100 times more numerous at higher redshift (z>1). For these galaxies, a large fraction of the light produced by stars reaches us in the range 100-2000 microns, after being reprocessed by dust. These galaxies become so important that they dominate the census of star formation in the Universe at 1<z<3.5. At higher redshift (z>4), quantifying the star formation rate density is a challenging endeavor. Today, most of the high-z measurements are based on UV emission emerging from the galaxies. However, these UV observations trace the un-obscured star formation and do not allow to directly measure the star formation from dusty galaxies. One of the crucial questions is therefore to quantify the role of these galaxies in the overall star formation budget at z>4.

To reach this goal, new deep and unbiased millimeter surveys are mandatory. Such surveys must combine high sensitivity and wide area, with good angular resolution to reduce confusion noise. Confusion is the ultimate limit of cosmological survey; it is inherent of deep surveys on a single dish telescope in the millimeter and sub-millimeter domain. Today, only a new generation of millimeter camera on a large telescope, with a high mapping speed, can fulfil the conditions to fully map the obscured star formation at high-z. This is one of the objectives of the cosmological surveys made with the NIKA2 camera at 1.2 and 2mm, installed on the IRAM 30m telescope. At LAM, our group is responsible of a Guaranteed Time Large Program, the "NIKA2 Cosmological Legacy Survey", with 300 hours on the GOODS North and COSMOS fields. We plan to almost finish the observations by the end of April 2022.

The thesis objectives are a) to obtain a complete view of the star formation rate at high-z; b) to bring new constraints on the evolution of galaxies (by probing for example the star formation in "normal" galaxies at high-z and determining if these galaxies follow the main sequence of star formation seen in the Universe at z<2 or if the starburst activity induced by galaxies interaction and fusion play an important role); c) to measure the distribution of star formation in large-scale structures with environment measurements.

The successful PhD candidate will contribute to the final data processing and analysis. She/he will extract the sources using multi-wavelength source extraction codes. Novel extraction techniques could also be explored, such as image segmentation based on Deep Learning algorithm. Using counterparts of detected millimeter sources using ancillary data, she/he will analyze their spectral energy distribution to measure stellar masses and star formation rate. Once the observations and galaxy detections are fully characterized, she/he will directly use them to constrain the history of dusty star formation by fitting for example our evolutionary model of galaxy evolution.

She/he will also help us to define the best strategy for follow up observations, in particular with the NOEMA and ALMA interferometers, to measure the redshift and gas mass of the most representative galaxies. Such measurements will be used to relate the star formation efficiency to other galaxy properties (mass, merger state, kinematics), to learn what regulates their star formation. Finally, she/he will be involved in the study of the environment/clustering of these objects, that will put strong constraints on models for the evolution of large scale structure, giving the link between star formation and dark mater halos mass.

This thesis offers the unique opportunity to participate to a pioneering observational project, within a dedicated team at LAM. Members of the NIKA2 deep field surveys include A. Beelen, M. Béthermin, V. Buat and D. Burgarella at LAM, N. Ponthieu and F.-X. Désert at IPAG, in addition to many others over the globe.

Bibliography:

“Searching for high-z DSFGs with NIKA2 and NOEMA”, Bing et al., 2021, arXiv:2111.00090