PhD project in ASTROPHYSICS

Title of the Project: A systematic search for ultra-bright high-z strongly lensed galaxies in Planck catalogues

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Scientific Case: A remarkable, largely unexpected result of Planck sub-mm all-sky surveys was the discovery of ultra-bright, extreme strongly lensed galaxies at $2<z<4$ (Cañameras et al. 2015; Harrington et al. 2016). These objects are of extraordinary scientific interest since the combination of total brightness, boosted by a factor of μ (typically in the range 10−50), and stretching of images by a factor $\approx\mu^{1/2}$ offers a unique opportunity to pierce into their internal structure and dynamics via high resolution follow-up observations. It becomes possible to reach spatial resolutions of tens of pc (Cañameras et al. 2017) and measure feedback-driven molecular outflows (Spilker et al. 2018; Cañameras et al. 2018, Jones et al. 2019). Resolved imaging and kinematics of early galaxies is the most direct and powerful way to learn about the complex physical processes governing galaxy formation and evolution and to discriminate among competing scenarios. So far about 20 strongly lensed galaxies have been found on Planck catalogues, over the limited sky regions covered by Herschel and South Pole Telescope (SPT) surveys. An extrapolation to the full high Galactic latitude ($|b|>20°$) sky implies a total number of ≈150, an excellent sample to get good or at least sufficient statistics over the peak of cosmic star-formation activity. As a first step towards a complete identification of Planck strongly lensed galaxies we have selected a sample of 228 candidates with $S_{545GHz} > 500$ mJy, distributed over the whole high-Galactic latitude sky. We recently observed sub-samples of these objects with the Australia Telescope Compact Array (ATCA; 95 h), with the NIKA2 mm imager at the IRAM 30m telescope (14 h) and with the SCUBA-2 bolometer array at the JCMT (20 h). Each object of our sample has been observed by at least one of such facilities.

Outline of the Project: This PhD project aims to carry out the reduction, analysis and scientific exploitation of these data, and to start a systematic program of high-resolution follow up observations of confirmed strongly lensed galaxies. They will constitute the first statistically significant complete sample of the brightest high-z sub-mm galaxies in the sky. Immediate applications of the new data will be: i) constraints on the brightest high-z tail of the 545 GHz counts, which constitute tests on one side of galaxy evolutionary models and, on the other side, of predictions for the high μ tail of the magnification distribution, which is a probe of evolution of large-scale structure; ii) constraints on the radio - far-IR correlation at high-z; iii) discovery of new high-z candidate proto-clusters of dusty galaxies. The PhD student will then submit proposals for measuring the redshifts of confirmed strongly candidates, for high-resolution observations with IR/sub-mm telescopes (such as ALMA and JWST) and for deep optical observations to identify the foreground lenses and measure their properties. These observations will allow us to extract unique information on the processes that govern galaxy formation and early evolution.

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