Towards the gold standard of composite star formation rate estimators

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Over the past decades, various methods have been derived for correcting star formation tracers for the attenuation, each with their own set of limitations, either theoretical or observational. Recently, composite (or hybrid) estimators have gained considerable traction to correct dust-sensitive star formation tracers such as the UV or Hα for the attenuation (e.g. Buat et al. 1999, 2005, Calzetti et al. 2007, Zhu et al. 2008, Kennicutt et al. 2009, Hao et al. 2011, Boquien et al. 2015b). They are based on the simple — yet powerful — idea that part of the energy emitted in the mid- and far-IR bands is coming from the reprocessing by dust of energetic photons emitted by massive stars. In other words, to correct the UV or Hα for the attenuation, we simply need to combine it with the IR: $L(H\alpha)_{intrinsic} = L(H\alpha)_{observed}+k\times L(IR)$, with k the appropriate scaling coefficient for the IR. The power of this method and at the same time its remarkable simplicity make it especially appealing. Unfortunately, different studies have yielded different estimators, showing the difficulty to measure reliably star formation in galaxies and the potential presence of ill-constrained biases.

To understand fundamental star formation laws such as the Schmidt-Kennicutt law, it is absolutely essential that we are in a position to measure reliably star formation in galaxies. Unfortunately, as we have just seen, we do not have the required tools yet, and those at our disposal do not even allow us to fully exploit currently available data. Our overarching goal for this project is two-fold. 1. We want to build universal composite Hα+IR SFR estimators parametrized on physical properties such as the local stellar mass for instance. These new estimators will be essential to overcome the limits of current estimators and exploit next-generation instruments. 2. We will use them to reassess some of the basic tenets on which stands our current understanding of star formation such as the Schmidt-Kennicutt law to constrain the physical processes at play in star formation.

To reach these objectives, we will build upon the works of Hao et al. (2011) and Boquien et al. (in prep.) on hybrid estimators. We will rely on a broad set of resolved multi-wavelength data, including Integral Field Unit observations, of nearby star-forming galaxies in combination with the state-of-the-art CIGALE model (http://cigale.lam.fr). The spatially resolved nature of the study, which will probe thousands of regions, will ensure the applicability of the results over a broad dynamical range in terms of physical properties (stellar mass, SFR, metallicity, etc.), and maximize their impact.

Then, by applying these new state-of-the-art estimators, we will be able to build spatially resolved Schmidt-Kennicutt diagrams, precisely at a scale where models can be discriminated. To do so, we will establish the relation between star formation and the gas reservoir, which we will compare with predictions from different models, bringing important constraints on the process of star formation in the local universe. This will serve as the new reference baseline in the era of ALMA, ELT, and JWST.