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Go beyond radial gradient: azimuthal variations of ISM abundance in 3D

I-Ting Ho

Max Planck Institute for Astronomy, Knigstuhl 17, 69117 Heidelberg, Germany

Abstract. Using 3D spectroscopy data from the TYPHOON Project (PI: B. Madore), I show convincing observational evidence that the ISM oxygen abundance traced by HII regions presents systematic azimuthal variations in NGC 1365 and NGC 2997. I discuss a possible physical origin and on-going efforts to explore the prevalence and cause of such variations.

Keywords. galaxies: ISM, galaxies: abundances, galaxies: spiral, galaxies: individual (NGC 1365, NGC 2997)

While radial abundance gradients shed light on the inside-out formation history of galactic disks, the azimuthal variations of ISM abundances can place critical constraints on gas mixing in galaxies (Roy & Kunth 1995). The degree of the azimuthal variations depends on how efficiently metals synthesised inside massive stars can be mixed with the surrounding medium when gas and stars orbit around the gravitational potential. Although radial gradients are now routinely measured by observations, azimuthal variations are still poorly constrained.

Recently, the increasing number of high quality integral field spectroscopy observations has begun to reveal the presence of azimuthal variations in the nearby Universe (Sanchez-Menguiano *et al.* 2016; Vogt *et al.* 2017). Robust mapping of metallicity in the warm ionised medium is facilitated by 3D spectroscopy in nearby galaxies achieving spatial resolutions approaching the typical scale of HII regions (< 100 pc). Using IFU data from the TYPHOON Project (PI: B. Madore), I have recently reported that in two nearby galaxies, NGC 1365 (Ho *et al.* 2017) and NGC 2997 (Ho *et al.* 2018), the HII region (strong line) oxygen abundances present clear, systematic azimuthal variations.

In NGC 1365, the variations are particularly pronounced, 0.2 dex. The oxygen abundances peak on the two $m = 2$ spiral arms and are lower in the inter-arm regions. Similar signatures are also seen in NGC 2997 but less pronounced, only about 0.05 dex. In Ho *et al.* (2017), we show that the azimuthal variations in NGC 1365 can be explained by two physical processes: gas undergoes localised, sub- kiloparsec-scale self-enrichment when orbiting in the inter-arm region, and experiences efficient, kiloparsec-scale mixing-induced dilution when spiral density waves pass through.

On-going IFU observations of nearby galaxies (e.g. MUSE large program by the PHANGS collaboration) and future surveys (e.g. SDSS IV Local Volume Mapper) will soon begin to address the prevalence and degree of azimuthal variations in nearby galaxies.

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