The MAGPI Survey: Using kinematic asymmetries to dissect drivers of dynamical evolution

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(1) Introduction:

Galaxy kinematics are sensitive to underlying mass distribution within galaxies, hence are useful to understand the evolution of galaxies. As galaxies evolve through different mechanisms, signatures remain in the **line-of-sight-velocity-distribution,** and by looking for these signatures we can better understand the physical processes driving galaxy evolution**.** The **Middle Ages Galaxy Properties in IFS (MAGPI;** Foster+21**)** Survey is collecting spectra from galaxies in the Universe's 'middle ages' at a spatial resolution similar to IFS surveys of the Local Universe to constrain what elements of galaxy evolution contribute to the **dynamical evolution of galaxies over cosmic time.** In this work, we investigate the physical drivers of **kinematic asymmetries** in a sample of star-forming & quiescent galaxies from the MAGPI & SAMI surveys.

(2) Kinematic Asymmetries:

Galaxy velocity maps can be modelled with a set of tilted rings (i.e., $V(R,\theta) = V_{rot}(R)\cos\theta\sin i$). Using **KINEMETRY** (Krajnovic+07), we can model the bulk rotation *and* non-circular motion in galaxies as Fourier Series (i.e., $\mathrm{V}(r,\theta) = V_{sys} + \sum_{m=1}^{M}(k_m\cos(m[\theta+\phi(r)])$ These non-circular motions lead to increased power to higher-order moments (i.e., $m > 1$) in the fitted series, commonly referred to as asymmetries. In **Bagge+24**, we normalize the higher-order moments to $S_{05} = \sqrt{0.5V_{rot}^2 + \sigma^2}$. This allows us to measure asymmetries in galaxies of all Hubble types by capturing the full kinematic 'budget'. Explicitly, our asymmetry measure is:

$$v_{asym} = \frac{k_2 + k_3 + k_4 + k_5}{S_{05}}$$

Fig. 1 shows the flux, velocity, dispersion & fitted KINEMETRY ellipse for a typical MAGPI galaxy.

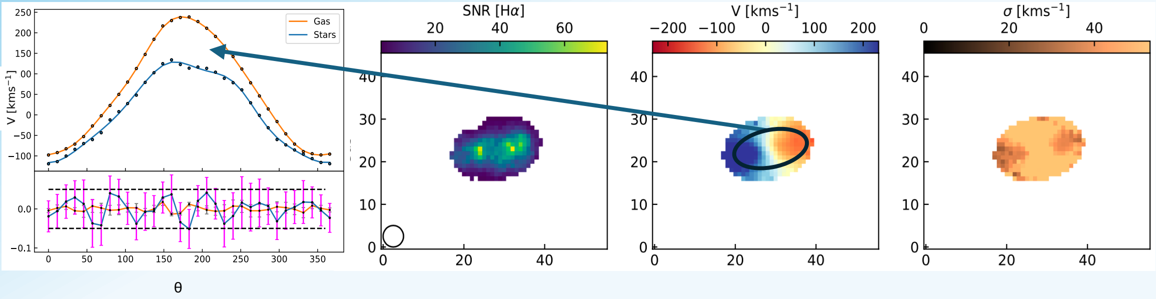
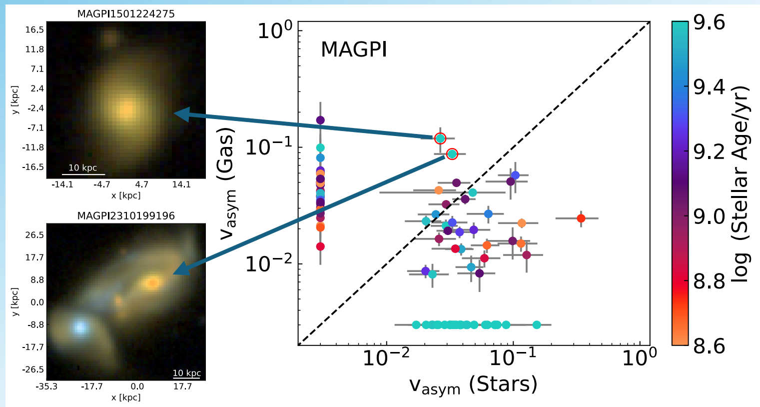


Fig. 1: Gas velocity maps for MAGPI1209131247. KINEMETRY measures the velocity and fits a Fourier Series along the ellipse with deviations from circular motion are encoded as higher-order moments.

(3) Stellar & gas asymmetries



Stars and gas can be thought as fundamentally different fluids (i.e., collisionless vs. collisional). Intuitively, we might expect that stellar asymmetries would last longer than gas asymmetries, and galaxies would scatter below the dashed line in **Fig.3**. We found that star-forming galaxies (where we detect ionized gas) with old stellar populations displayed larger gas asymmetries compared to their stars. We suspect that *recent, but slow* gas accretion is disturbing the gas, while keeping the stars stable. Interestingly, this happens in galaxies without an obvious neighbour.

Fig. 3: v_{asym} (Gas) vs. v_{asym} (Stars) for MAGPI galaxies. The two galaxies with largest gas asymmetries are shown to left. We suspect both these galaxies are slowly accreting gas, but with different mechanisms. A gas-rich merger in MAGPI2310199196 & cold accretion in MAGPI1501224275

(4) Trends persist at low-redshift:

MAGPI galaxies were specifically chosen to be a spatial resolution comparable to local IFS surveys, like the SAMI Galaxy Survey (Bryant+15, Scott+18,Croom+21), After matching distributions of stellar mass & mean-stellar age SAMI galaxies with our MAGPI sample. We also find that star-forming galaxies with old stellar populations typically have larger gas asymmetries compared to their stellar asymmetries.

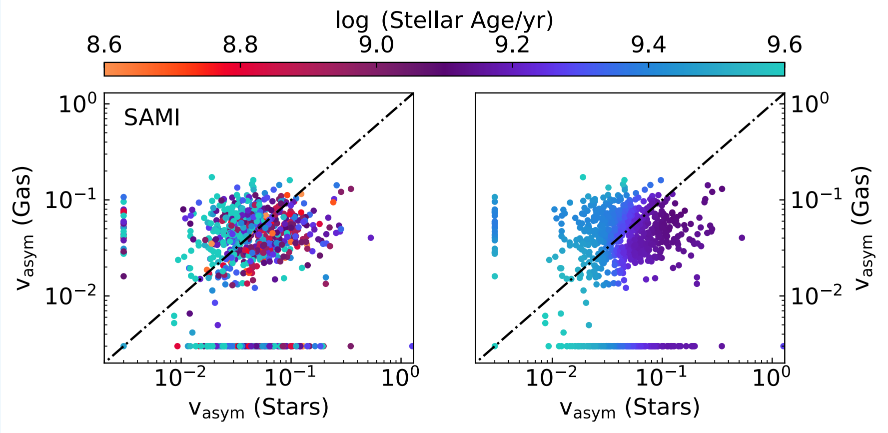


Fig. 4: v_{asym} (Gas) vs. v_{asym} (Stars) for SAMI galaxies. Even at low-redshift, we find that star-forming galaxies with old stellar populations have larger gas asymmetries. Data on the right has been LOESS smoothed to bring out the trend

Check out the paper below!

References: Bagge et al., 2024, RAS, MNRAS, blah, blah, Bryant et al., 2015, RAS, MNRAS, **447,** 3, 2857–2879, Croom et al., 2021, RAS, MNRAS, **505**, 1, 991-1016, Foster et al., 2021, PASA, **38,** e031, 24 pages, Krajnovic et al., 2006, RAS, MNRAS **366,** 3, 787–802, Scott et al.,2018, RAS, MNRAS, **481,** 2, 2299-2319