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A 3D view of the Hydra I galaxy cluster core - I. Kinematic substructures

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Abstract. We used FORS2 in MXU mode to mimic a coarse 'IFU' in order to measure the 3D large-scale kinematics around the central Hydra I cluster galaxy NGC 3311. Our data show that the velocity dispersion field varies as a function of radius and azimuthal angle and violates point symmetry. Also, the velocity field shows similar dependence, hence the stellar halo of NGC 3311 is a dynamically young structure. The kinematic irregularities coincide in position with a displaced diffuse halo North-East of NGC 3311 and with tidal features of a group of disrupting dwarf galaxies. This suggests that the superposition of different velocity components is responsible for the kinematic substructure in the Hydra I cluster core.

Keywords. galaxies: elliptical and lenticular, cD - galaxies: kinematics and dynamics - galaxies: halos - galaxies: individual (NGC 3311)

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1. Introduction, target and method

The mass determination of central cluster galaxies based on kinematical data normally uses simplified assumptions of virial equilibrium and spherical symmetry. The round appearance of these galaxies and the smooth distribution of hot X-ray emitting gas might suggest that these assumptions are justified. On the other hand, it has been shown that the halos of massive ellipticals grow by a factor of about 4 in mass since z=2 (van Dokkum *et al.* 2010). The mass growth is dominated by the accretion of low mass systems (minor mergers). Thus, one might expect that accretion events leave kinematical signatures in the phase space of the outer stellar population especially of central cluster galaxies.

Here we present the vivid case of the central giant elliptical of the Hydra I cluster, NGC 3311. This early-type galaxy dominated cluster is regarded as dynamically evolved. Recent photometric and kinematical studies of the diffuse stellar light, planetary nebulae and globular clusters in the core of Hydra I, however, have shown that 1) NGC 3311 exhibits a steeply rising velocity dispersion profile (Ventimiglia *et al.* 2010, Richtler *et al.* 2011), 2) the velocity dispersion profiles differ from each other in different azimuthal directions, as judged from longslit analyses (Ventimiglia *et al.* 2011, Richtler *et al.* 2011), and 3) the diffuse light is not centered around NGC 3311's main spheroid, but it is displaced towards the North-East by about 15 kpc (Arnaboldi *et al.* 2012).

In order to find kinematic signatures of these substructures and to disentangle the past and present active assembly history of the Hydra I cluster core, we used FORS2 in MXU mode (ESO programme 088.B-0448, PI: T. Richtler) to mimic a coarse 'IFU'. Our novel approach is to place short slits in an onion shell-like pattern around NGC 3311 to measure its 3D large scale kinematics out to 3 effective radii. Sky slits were positioned far outside of NGC 3311's main body and bright halo. The borders of the 'IFU' spaxels

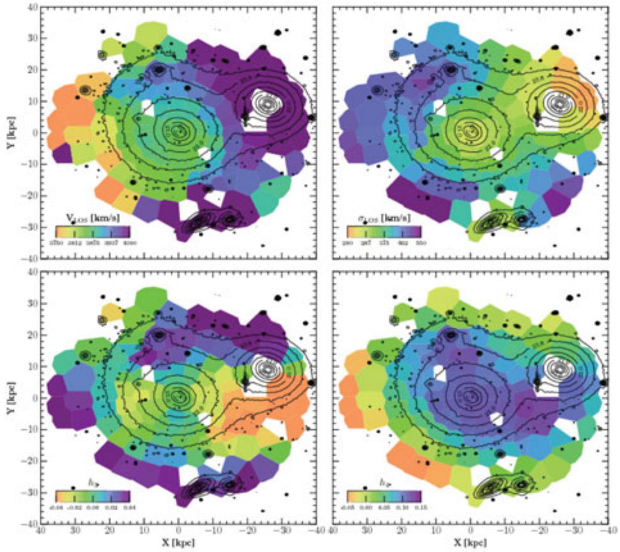

Figure 1. Upper left: Radial velocity map. **Upper right:** Velocity dispersion map. **Lower left:** Skewness (h3) map. **Lower left:** Kurtosis (h4) map. All maps were smoothed with a locally weighted scatterplot smoothing algorithm (Cleveland 1979). The contours are surface brightness levels of NGC 3311 (in the center) and NGC 3309 (on the right) V-band light between 19 and 23.5 mag/arcsec^2 in steps of 0.5 mag.

were defined via Voronoi tesselation to create kinematic maps (see Fig. 1). The S/N of our final spectra ranges from >20 to 2 from the inner to the outer radii.

2. Results and conclusions

The main results of our analysis, shown in Fig. 1, are: 1) there are pronounced azimuthal variations both in radial velocity and velocity dispersion as a function of galactocentric distance, explaining the above mentioned discrepancies from previous longslit results; 2) in the North-East there are significant small scale variations in both radial velocity and velocity dispersion data points; 3) the very large velocity dispersion values in some parts of the cluster core ($\sigma > 500$ km/s) probably point to a superposition of kinematical substructures; and 4) the displaced diffuse stellar halo around NGC 3311 coincides with regions of positive h3 and h4 values, also evidence for more than one velocity component in the stellar halo.

We conclude that the stellar halo around NGC 3311 in the core of Hydra I is still forming and is not in dynamical equilibrium. Probably, a group of infalling dwarf galaxies and their tails are responsible for the kinematical substructures. The general lesson is that one has to take care when inferring the properties of the central dark matter halo around NGC 3311 from kinematical data.

References

Arnaboldi, M., Ventimiglia, G., Iodice, E., Gerhard, O., & Coccato, L., 2012, *A&A*, 545, 37
Cleveland, W. S., 1979, *JASA*, 74, 829
Richtler, T., Salinas, R., Misgeld, I., *et al.* 2011, *A&A*, 531, 119
van Dokkum, P. G., Whitaker, K. E., Brammer, G., *et al.* 2010, *ApJ*, 709, 1018
Ventimiglia, G., Gerhard, O., Arnaboldi, M., & Coccato, L., 2010, *A&A*, 520, 9
Ventimiglia, G., Arnaboldi, M., & Gerhard, O., 2011, *A&A*, 528, 24