Galaxy Evolution with Velocity Fields

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GOALS: Measuring kinematics of galaxies is fundamental to constrain galaxy evolution since it traces directly the total galaxy mass distribution, which in turn drives the photometric and morphological properties. In addition, two-dimensional velocity fields hold unique features to disentangle various processes like merging, tidal and ram-pressure interactions. But traditional 3D spectroscopy is rather expensive and delivers limited information only. Here, we present our method and first results for 0<z<1.

Our METHOD: Use slit masks with FORS2@VLT: observe each galaxy with three slit positions (3 masks). Combine to grid. Advantages:
- matched spatial coverage (~7”x3”)
- sufficient spatial resolution (0.25”x1”)
- large wavelength coverage (3300Å) — many diagnostic lines measurable
- high efficiency: large target number (20-30); economic exposure times (8h) [Ziegler et al. 2009 ESO Messenger 137]

The DATA: Each slit yields position-velocity pairs (“rotation curves”) that are transformed to a common coordinate system. Here, an example velocity field (VF) of a cluster galaxy at z=0.2 displayed as binned independent data points and linearly interpolated for easier visualization. [Kutdemir et al. 2008 A&A 488, 117]

Kinemetry Analysis:

Using kinemetry package [Krajnovic et al. 2006] VF is fitted with ellipses (top left) each characterized by center, position angle \( \Gamma \) and flattening \( q \). Deviations from ellipses quantified by harmonic Fourier expansion. Residual map (top right) is model subtracted from observed field. Simple rotation map (circular components only) and its residual is shown in lower panels. [Kutdemir et al. 2008 A&A 488, 117]

VF’s extracted from N-body/SPH simulations carried out for dark matter halo, stellar body and collisional gas clouds including prescriptions for star formation and feedback. Radial profiles displayed for position angle \( \Gamma \), flattening \( q \) and Fourier coefficient \( k_3 \) (bulk motion) and \( k_5 \) (separate kinematic components). [Kronberger et al. 2007 A&A 473, 761 & 2008 A&A 483, 783]

Irregularity parameters:

\( \Delta \Phi \): Mean difference between kinematic and photometric position angles of ellipses / isophotes

\( \sigma_{PA} \): Standard deviation of kinematic position angle from its mean

\( k_{3,5} = (k_3 + k_5)/k_1 \): average of higher Fourier coefficients

Results:

<table>
<thead>
<tr>
<th>Table 10. Irregularity fraction.</th>
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<tbody>
<tr>
<td>field &amp; cluster</td>
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<tr>
<td>only field</td>
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<tr>
<td>only cluster</td>
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Distributions of galaxies according to irregularity parameters:
top: local SINGS sample; bottom: our distant galaxies divided into field (green) and cluster (blue)
- no significant difference between distant field and cluster galaxies
- there exist also very distorted field galaxies at z>0.2 with any visible neighbor
- distant field galaxies more often irregular than local field galaxies
- spiral galaxies at z>0.2 still build-up their disks via minor merging and accretion