Estimation of kinematic parameters in CALIFA galaxies: no-assumption on internal dynamics

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CALIFA Survey

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ABSTRACT

We propose a simple approach to homogeneously estimate kinematic parameters of a broad variety of galaxies (elliptical, spirals, irregulars or interacting systems). This methodology avoids the use of any kinematical model or any assumption on internal dynamics. This simple but novel approach allows us to determine: the frequency of kinematic distortions, systemic velocity, kinematic center, and kinematic position angles which are directly measured from the two dimensional-distributions of radial velocities. We test our analysis tools using the CALIFA Survey [1]. .

SYSTEMIC VELOCITY

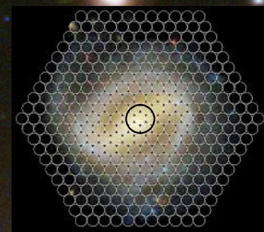


Figure 1: The systemic velocity is estimated by averaging the radial velocities within an aperture twice the full-width-half-maximum of the PSF (3.7 arcsec in radius for CALIFA [2]) centered in the optical nucleus. The standard deviation of these radial velocities are taken as an indicator of the uncertainty.

KINEMATIC CENTER

The kinematic center (KC) of an ideal purely rotating disk galaxy has a zero rotation velocity, and it is the location of the largest velocity gradient in the galaxy. To estimate its location, we can computed the average absolute difference of the velocity for each spaxel with the velocity of its surrounding spaxels. The resulting image emphasizes those regions in the velocity field where the data are changing rapidly, and its peak should indicate the KC for galaxies showing regular motions. For complex kinematics, the velocity gradient distribution shows presence of several velocity gradient peaks that indicate departures from pure rotation.

NGC 2347 ionized gas velocity field (a), and velocity gradient distribution (b).

NGC 5947 ionized gas velocity field (a), and velocity gradient distribution (b).

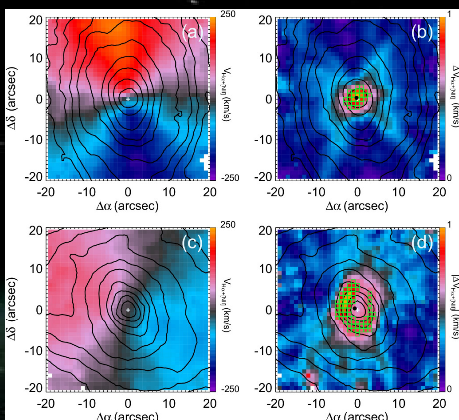


Figure 2: Estimation of the KC for a galaxy with a single peak in the velocity gradient image, and for an object with a ring structure in the central region of the velocity gradient distribution. Green open squares indicate the velocity gradient pixels used to estimate the KC location through the average of their positions weighted by their gradient values. Contours from the stellar continuum are overlapped. The white plus sign marks the location of the optical nucleus (peak of the stellar continuum) and the black circle indicates the estimated KC position (see [3]).

According to the structures of the velocity gradient images we classify galaxies from the CALIFA Survey in:

- (SGP) Single Gradient Peak: Galaxies with a conspicuous velocity gradient peak
- (MGP) Multi Velocity Gradient Peak: Galaxies with clear structures in the velocity gradient map
- (UGP) Unclear Gradient Peak: A reliable Gradient Peak can not be identified.

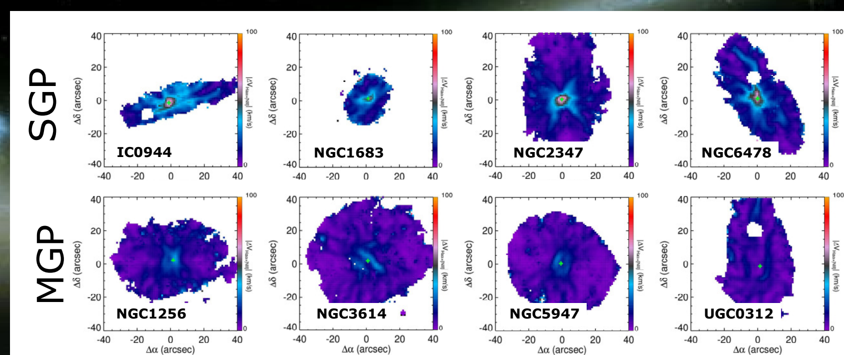


Figure 3: Velocity gradient maps obtained from Hα+[NII] velocity fields for a set of CALIFA objects. These galaxies were classified as SPG (upper panels) and MGP (lower panels).
•SGP class galaxies should correspond to objects dominated by rotation
•MGP class galaxies suggest the presence of dynamically distinct components (e.g. bar); other processes than pure rotation are playing a role in the dynamical state of these objects

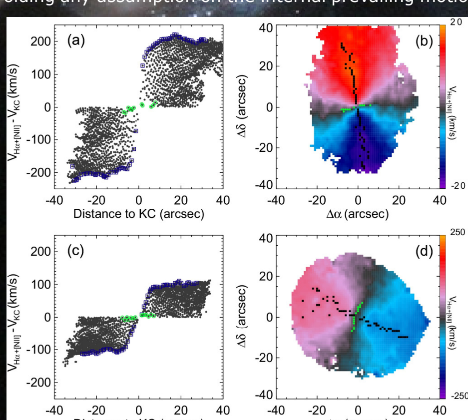
POSITION ANGLE OF KINEMATIC AXES

The orientation of velocity fields can be directly obtained from polar position of the spaxels in the kinematic line of nodes [4],[5]: 1) plot a distance-velocity diagram for the radial velocity of each spaxel. KC as reference center; 2) Select those spaxels with the largest velocity difference to KC at each radius, and tracing a pseudo-rotation curve; 3) Locate selected spaxels on the velocity field to trace the kinematic line of nodes; (4) Average the polar coordinates of the selected spaxels. To estimate the minor kinematic axis, do the same but in 2) select those spaxels with the lowest velocity differences to KC at any radius.

Figure 4: Estimating the position angle of kinematic axes directly from measured radial velocities and avoiding any assumption on the internal prevailing motions .

NGC 2347 pseudo-rotation curve (a), and velocity field showing the trace kinematic axes (b).

NGC 5947 pseudo-rotation curve (c), and velocity field showing the trace kinematic axes (d).



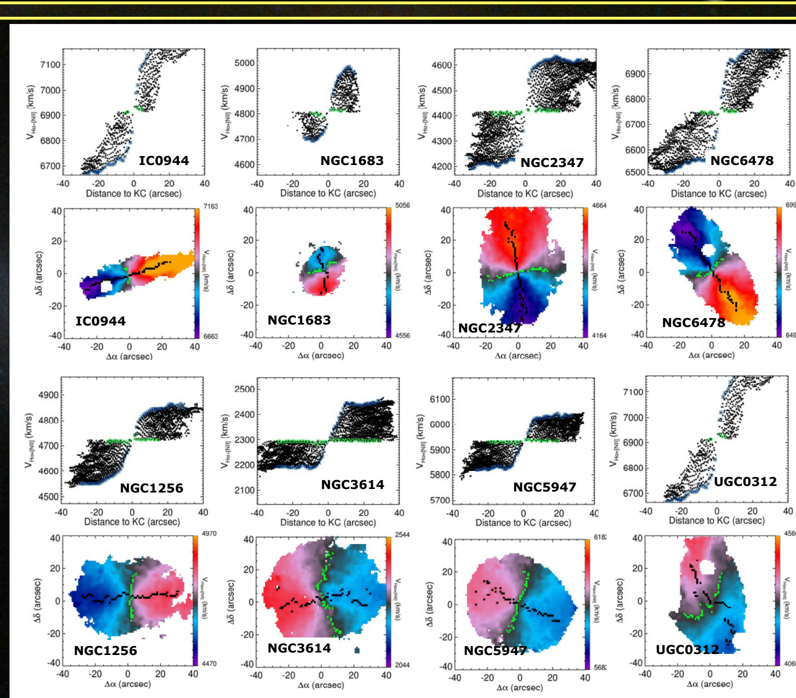


Figure 5: Estimating the position angle of kinematic axes for the SGP and MGP galaxies in Fig. 3. Selected spaxels tracing kinematic minor (green dots) and major (blue squares) are shown.

REFERENCES: [1] Sánchez, Kennicutt, Gil de Paz et al. 2012, A&A, 538, A8; [2] Husemann, Jahnke, Sánchez et al. 2013, A&A, 549,A87; [3] García-Lorenzo, Márquez, Barrera-Ballesteros et al. 2015, A&A, 573,A59; [4] Nicholson, Bland-Hawthorn, & Taylor 1992, ApJ, 387, 503 ; [5] Bland, Taylor, & Atherton 1987, MNRAS, 228, 595);

CALIFA Survey Web Page: califa.caha.es