Galaxy Disks and Disk Galaxies
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SAURON Observations of Disks in Early-Type Galaxies

M. Bureau, Y. Copin, E. K. Verolme, P. T. de Zeeuw

Sterrewacht Leiden, Postbus 9513, 2300 RA Leiden, Netherlands

R. Bacon, Eric Emsellem

CRAL-Observatoire, 9 Avenue Charles-André, 69230 Saint-Genis-Laval, France

Roger L. Davies, Harald Kuntschner

Physics Department, University of Durham, South Road, Durham DH1 3LE, United Kingdom

C. Marcella Carollo

Department of Astronomy, Columbia University, 538 West 120th Street, New York, NY 10027, U. S. A.

Bryan W. Miller

Gemini Observatory, Casilla 603, La Serena, Chile

G. Monnet

European Southern Observatory, Karl-Schwarzschild Strasse 2, D-85748 Garching, Germany

Reynier F. Peletier

Department of Physics and Astronomy, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom

Abstract. We briefly describe the SAURON project, aimed at determining the intrinsic shape and internal dynamics of spheroids. We focus here on the ability of SAURON to identify gaseous and stellar disks and to measure their morphology and kinematics. We illustrate some of our results with complete maps of NGC 3377, NGC 3623, and NGC 4365.

1. The SAURON Project

We are carrying out a study to determine the distribution of intrinsic shapes of early-type galaxies and bulges and to constrain the range of internal velocity, age, and metallicity distributions realized in luminous galaxies. Of interest are the observed dichotomy of central cusp slopes, the dynamical role of central massive black holes, and the relation between the kinematics and stellar populations.

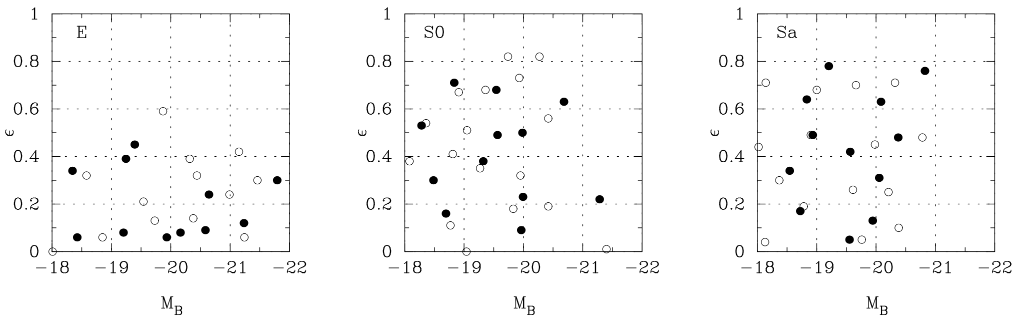

Figure 1. The SAURON representative sample of E, S0, and Sa galaxies. *Filled circles:* Cluster galaxies. *Empty circles:* Field galaxies.

Such goals require the use of wide-field spectroscopy with complete spatial coverage, a large bandpass, and sufficient spectral resolution. SAURON was designed specifically to meet these goals. In its low spatial resolution mode, it has a $41'' \times 33''$ field-of-view sampled at $0\farcs94$ and a $4800 - 5400$ Å wavelength range with 3.6 Å resolution (90 km s^{-1} instrumental dispersion). The instrument is fully described in Bacon et al. (2001).
For the SAURON project, we are observing a *representative* sample of spheroids covering the full range of environment, nuclear cusp slope, rotational support, and apparent flattening. The sample was chosen from a complete list of galaxies to populate homogeneously six (ϵ, M_B) planes. These planes, representing E/S0/Sa and field/cluster galaxies, are illustrated in Figure 1. The data are reduced in a uniform manner using a pipeline specifically developed for SAURON.

2. SAURON Observations of Disks

The wavelength range covered by SAURON for nearby galaxies includes many important emission and absorption lines, such as Hβ, [OIII], Mgb, Fe1, and [NI]. The emission lines allow us to meaure the total intensity and mean velocity of the ionized gas, but our main goal is to measure the full stellar line-of-sight velocity distribution from the absorption lines (i.e. v, σ, h_3, h_4) and to measure line-strength indices. Below, we present examples of a gaseous disk (NGC 3377) and a stellar disk (NGC 3623) embedded in a larger spheroid. We also show line-strength maps for a galaxy harboring a central kinematically decoupled component (NGC 4365). Disks, asymmetries, and evidence of triaxiality are all easily detected (see de Zeeuw et al. 2001).

2.1. A Barred Gaseous Disk in NGC 3377

NGC 3377 is a large E6 galaxy in the Leo group, previously thought to be axisymmetric. Figure 2 shows the [OIII] total intensity and velocity field obtained with SAURON. The ionized gas distribution is strongly non-axisymmetric, resembling a bar. The gaseous kinematics also suggests a bar-like perturbation, showing minor-axis rotation and a twist of the kinematic major axis. Evidence of triaxiality is also seen in the SAURON stellar velocity field of NGC 3377, which shows significant minor-axis rotation (Bacon et al. 2001).

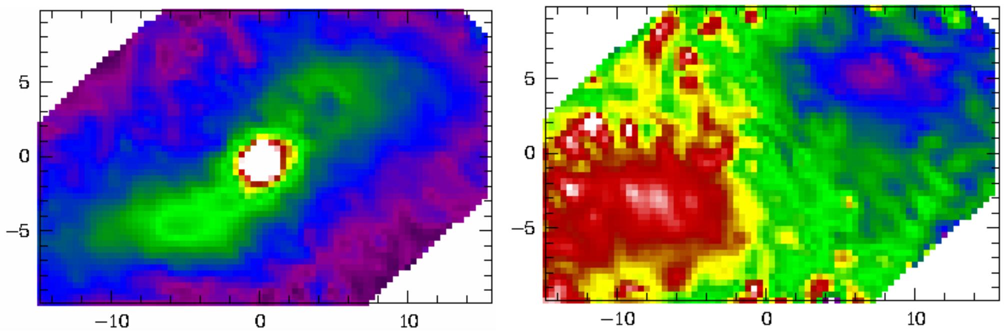

Figure 2. The SAURON [OIII] total emission line intensity (*left*) and velocity field (*right*) for the E6 galaxy NGC 3377. The scales are in arcseconds and velocities extend from -140 to 140 km s^{-1}.

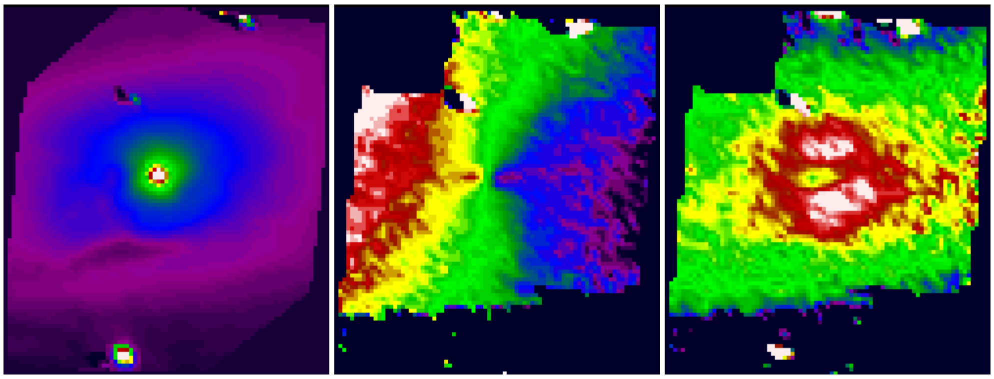

Figure 3. The SAURON reconstructed luminosity distribution (*left*), velocity field (*center*), and velocity dispersion field (*right*) for the SABa galaxy NGC 3623. Each field is approximately $48'' \times 62''$ and represents the mosaic of two partially overlapping SAURON pointings. Velocities range from -180 to 180 km s^{-1} and dispersions from 80 to 180 km s^{-1}.

2.2. A Central Stellar Disk in NGC 3623

NGC 3623 (M 65) is another highly-inclined galaxy in the Leo group, but it is of much later type than NGC 3377, SABa(rs). It is part of the Leo triplet with NGC 3627 and NGC 3628 but does not appear to be interacting. NGC 3623's kinematics has barely been studied and the SAURON observations provide the first glimpse of its dynamics. Figure 3 shows the reconstructed luminosity distribution, velocity field, and velocity dispersion field obtained with SAURON. They encompass most of the bulge. The large-scale velocity field reveals minor-axis rotation, in agreement with the presence of a bar. In addition, a quasi edge-on disk is present in the center, where the isovelocity contours flatten out abruptly. This disk appears as a central depression in the velocity dispersion field, and its effects are also seen in the h_3 and h_4 maps (not shown).

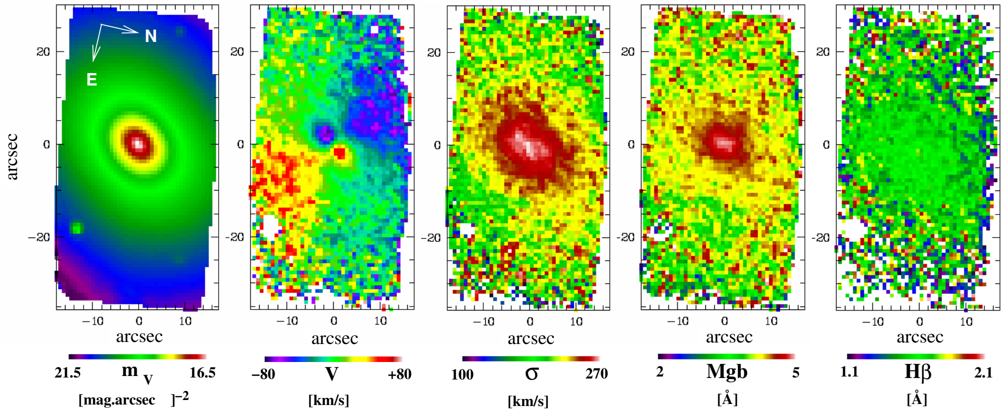

Figure 4. The SAURON reconstructed luminosity distribution, velocity, velocity dispersion, Mgb, and Hβ maps for the E3 galaxy NGC 4365. The data represent the mosaic of two partially overlapping SAURON pointings.

2.3. The Kinematically Decoupled Core of NGC 4365

NGC 4365 is a large E3 galaxy in Virgo. It was known to possess a kinematically decoupled core, rotating perpendicularly to the outer parts (in projection; see Surma & Bender 1995). Figure 4 presents maps of the reconstructed luminosity distribution, velocity, and velocity dispersion, as well as the Mgb and Hβ line-strength maps in the Lick/IDS system. The SAURON data reveal the morphology, kinematics, and line-strengths of the stars over most of the body of the galaxy. The two components with misaligned angular momenta are easily recovered and suggest that the galaxy is triaxial or at least that it departs significantly from axisymmetry. The velocity dispersion and line-strengths follow the light distribution and show no sign of the central component. The line-strengths suggest a constant luminosity-weighted age of ≈ 14 Gyr across the galaxy, accompanied by a decrease of the metallicity with radius; only the very center may be 2–3 Gyr younger. These results imply that the kinematic configuration is stable over a Hubble time and that the entire galaxy experienced a similar star formation history, most likely involving considerable gaseous dissipation (see Davies et al. 2001 for more details).

References

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