SAURON Observations of E/S0/Sa Galaxies

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Abstract

We present the first results from a new and unique integral-field spectrograph, SAURON. It has a large field of view and high throughput and is primarily built for the study of stellar and gaseous kinematics in galaxies. Its aim is to carry out a systematic survey of the velocity fields, velocity dispersions, and line-strength distributions of nearby ellipticals and spiral bulges. Its wide field is especially useful for the study of complicated velocity structures. Together with other spectroscopic data, images, and dynamical modeling, SAURON will help to constrain the intrinsic shapes, mass-to-light ratios, and stellar populations of elliptical galaxies and bulges.

In this poster, we describe SAURON, its specifications, the goals of the scientific program, the sample of galaxies, the dynamical modeling, and some preliminary results obtained during the first science observing run.

Instrument

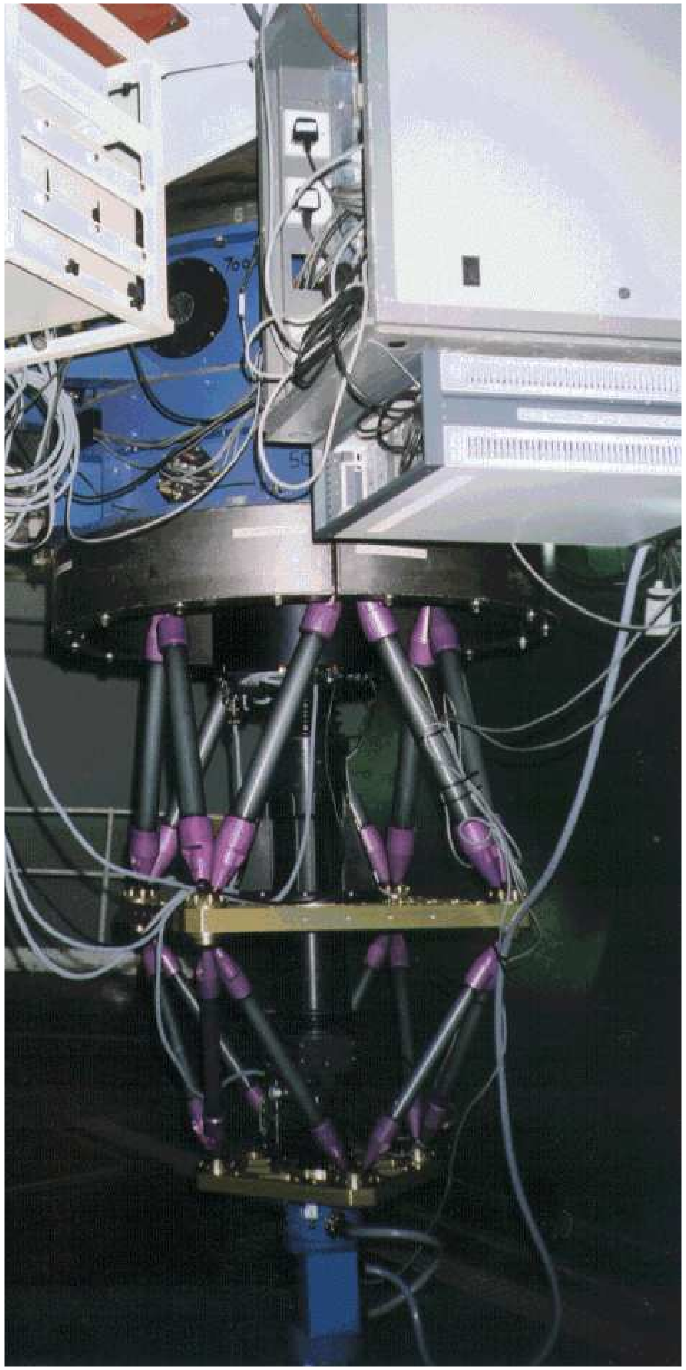
SAURON (Spectroscopic Areal Unit for Research on Optical Nebulae) is a TIGER-like integral field spectrograph [1] with an array of 1500 square lenses, built for the William Herschel Telescope of the Isaac Newton Group on La Palma. It is the result of a collaboration between three institutes: the Sterrewacht Leiden, the Observatoire de Lyon, and the University of Durham. Basic specifications for the high (HR) and low (LR) resolution modes are presented in Table 1, along with a photograph of the instrument mounted at the telescope.

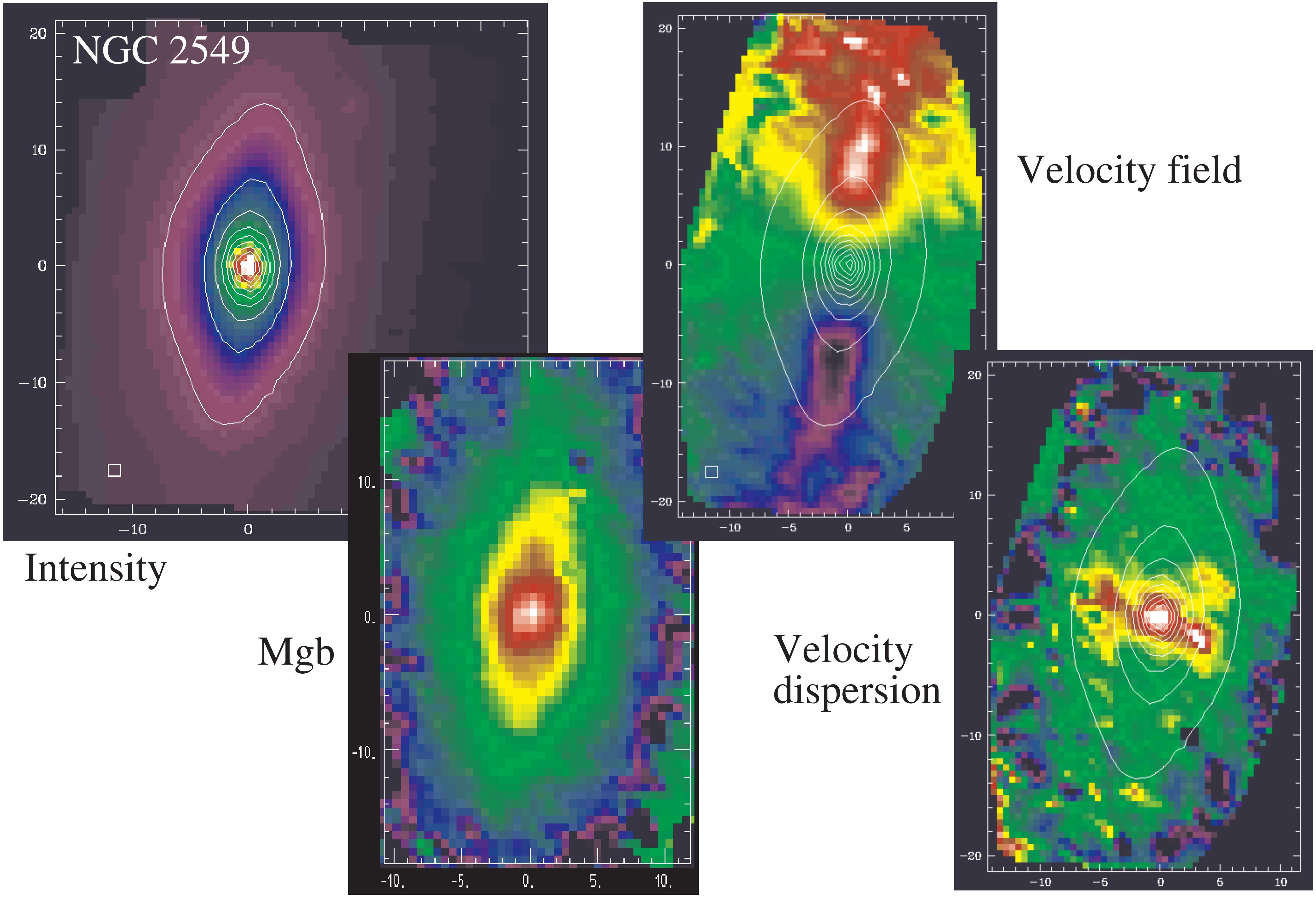
The data are reduced in a standard manner, archived, and analysed using a pipeline especially developed for SAURON. The pipeline is modeled after the XOASIS package. An optimal extraction algorithm is used to remove contamination between overlapping spectra.

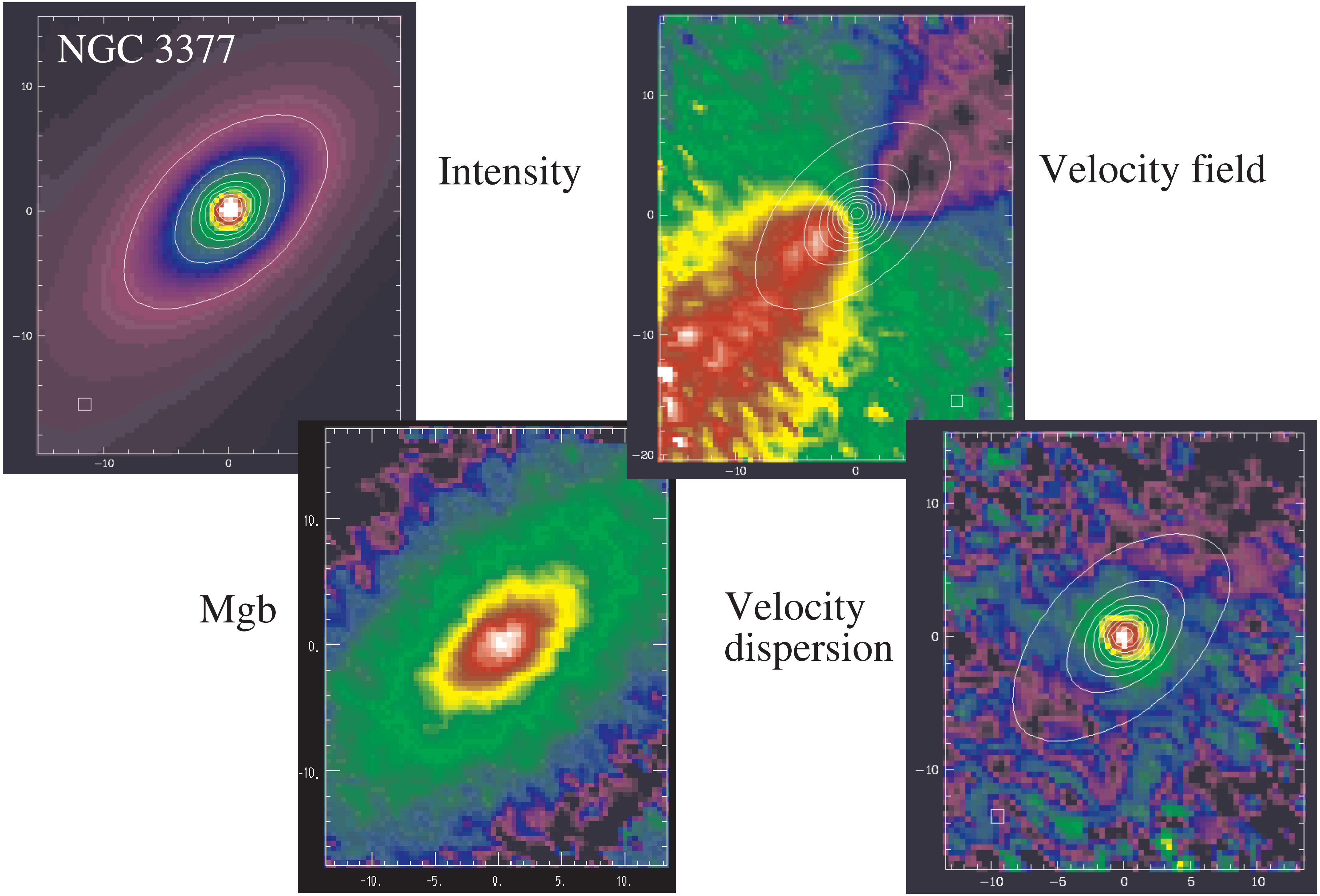
The figures show some results from the first SAURON observing run in February 1999. Reconstructed total intensity, velocity, velocity dispersion, and Mg_2 line-index maps are presented for three galaxies: NGC 2549 [S0/a(r)], NGC 3377 [E6], and NGC 3379 [E0]. All show a differentially rotating stellar disk and increasing velocity dispersion toward the center. The large angular extent of the maps should be noted.

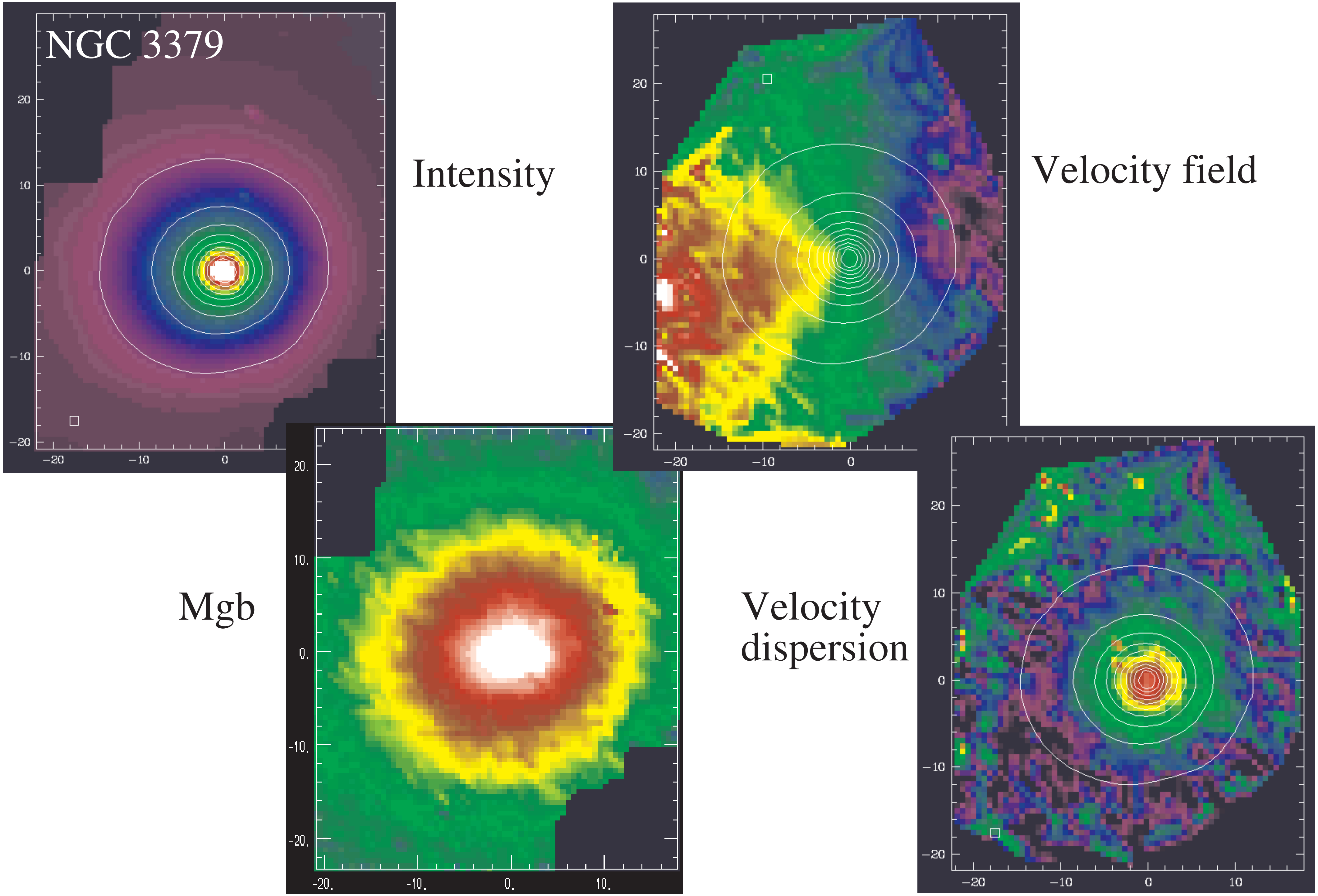
SAURON Specifications

Property	Mode LR	Mode HR
Projected size of lenslet	$0\farcs94$	$0\farcs26$
Field of view	$40''\times33''$	$11''\times9''$
Spectral resolution (FWHM)	3.6 Å	2.8 Å
Wavelength coverage	4810 Å–5400 Å	
Number of object lenslets	$\approx$1500	
Number of sky lenslets	$\approx$100	
Grism	514 lines mm^{-1}	
Spectral sampling	1.1 Å pix^{-1}	0.9 Å pix^{-1}
Instrumental dispersion (σ)	90 km s^{-1}	70 km s^{-1}
Spectra separation/PSF ratio	1.4	2.3
Important spectral features	Hβ, [OIII], Mg$_b$, FeI, [NI]	
Calibration lamps	Ne, Ar	
Telescope	William Herschel 4.2-m	
Detector	EEV12 2148$\times$4200	
Pixel size	13.5 μm	
Efficiency (optics/total)	$\approx$35%	$\approx$14%




NGC 2549
Intensity
Mgb
Velocity field
Velocity
dispersion


NGC 3377
Intensity
Velocity field
Mgb
Velocity
dispersion


NGC 3379
Intensity
Velocity field
Mgb
Velocity
dispersion

Description of the Project

The intrinsic shapes and internal dynamics of ellipticals and bulges have long been the subject of debate. Many galactic components (e.g. halos and bars) and entire galaxies (e.g. giant ellipticals) are known to have triaxial shapes. Questions that require further investigation include:

- What is the distribution of the intrinsic triaxial shapes?
- What is, at a given shape, the range in internal velocity distributions?
- What is the dynamical role of massive central black holes?
- What is the relation between the stellar and gaseous kinematics and the stellar populations?

With this in mind, the SAURON project has the following goals:

- To provide a full census of nearby galaxies along the Hubble sequence
- To extract complete 2D velocity fields and line strengths for the observed galaxies
- To combine the results with state of the art (triaxial) modeling

Sample

To achieve SAURON's goals, we aim to probe the structure and kinematics of a representative sample of about 75 early-type galaxies. A subsample of 60 objects is divided equally between:

- Ellipticals (E,E/S0), lenticulars (S0/E,S0), and early-type spirals (S0/a,Sa)
- Cluster and field objects

Galaxies within these 6 resulting groups have been chosen to spread the entire range of absolute magnitude and apparent flattening, and an effort was made to cover as much as possible a range of cusp slope, rotational support, Mg_2 index, etc. Additional instrumental constraints are:

- $-6^\circ < \delta < 64^\circ$ (instrument flexure)
- $V_{sys} < 3000$ km s^{-1} (spectral coverage)
- $M_B < -18$ mag (sensitivity)

Galaxies with HST imaging/spectroscopy and with extensive ground-based data were favoured, as constraining the kinematics on various scales is crucial for our project.

Dynamical Modeling

The dynamical modeling uses all appropriate imaging and spectral data available:

- HST and OASIS spectra to constrain the mass of central black holes
- SAURON data cubes to determine the stellar and gaseous velocity profiles within $1R_e$
- Long-slit spectra to detect dark matter haloes at $(1-2)R_e$
- HST, ground-based images, and SAURON line-strengths to gain insight into the structure and M/L of the stellar component

We use Schwarzschild's numerical orbit superposition method. It makes no assumptions about the shape of the distribution function, and the resulting models depend on all three integrals of motion. The method has already been implemented for the spherical and axisymmetric cases [3,4]. Successful applications include the determination of the BH mass in the E3 galaxy M32 [5] and in the E7/S0 Virgo galaxy NGC 4342 [2]. Axisymmetric and triaxial modeling of the SAURON galaxies is in progress. This will fully characterize the systems and their embedded stellar disks.

References

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SAURON Specific Technical Papers

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