Ionized Gas in Spheroids: The SAURON Survey

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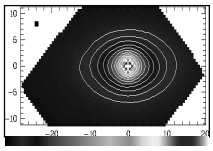
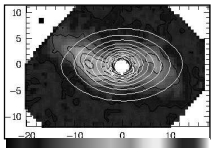
Introduction

Constructing a coherent picture of the formation and evolution of galaxies requires a wide understanding of their present dynamical state. With this in mind, we are carrying out a systematic study of the morphology, kinematics, and line-strength distributions of a representative sample of nearby cluster and field E, S0, and Sa galaxies by means of our panoramic integral-field spectrograph **SAURON** [1] (53 of 72 objects have been observed so far). The goal of the project is to determine the intrinsic shapes of the galaxies, their orbital structure, the mass-to-light ratio as a function of radius, the age and metallicity of the stellar components, the dynamical role of decoupled cores and nuclear black holes, the relation between the stellar (and gaseous) kinematics, and the star formation history.

Here, we present **SAURON** maps of NGC 3377, NGC 5813, and NGC 7742, focusing on the Hβ and [OIII] emission line distributions and the gas kinematics [2]. The maps, based on 4x30 min exposures per pointing, illustrate the variety of gas morphologies and kinematics displayed by nearby spheroids.



total intensity

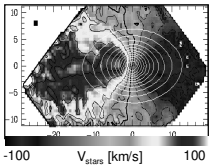


gas intensity

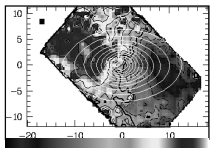
NGC 3377 is an E6 galaxy in the Leo I group. It has a total absolute magnitude M_B=-19.24, with a steep central luminosity profile (power-law galaxy [3]) and evidence for a massive central black hole [4].

The stellar velocity field shows a well-defined rotation pattern and a clear departure from axisymmetry: the zero velocity curve is tilted by about 10° with respect to the minor axis.

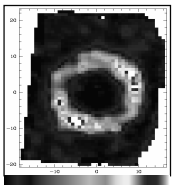
The distribution of [OIII] gas has a bar-like morphology with signs of spiral arms. This structure is likely a manifestation of the triaxiality suggested by the stellar kinematics.



-100 V_{stars} [km/s] 100

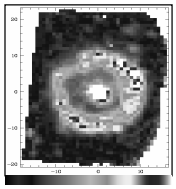


-140 V_{gas} [km/s] 170



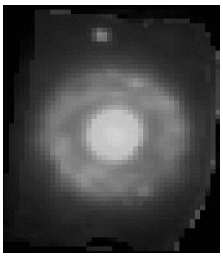
[OIII] emission

Emission from Hβ and [OIII] is easily detected. Most of the emission is confined to a ring of star formation surrounding the bulge. Hβ is dominant everywhere (Hβ/[OIII] = 7 to 16.5 in the ring), but the peak intensities of Hβ and [OIII] do not coincide; there is no detectable [OIII] in the center.

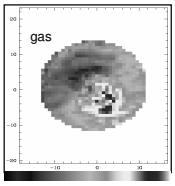


Hβ emission

NGC 7742 is a face-on spiral galaxy classified as S(r)b in the RC3 (M_B=-19.76). The image in the middle is composed of [OIII] (blue), blue continuum (green) and red continuum (red) derived from the **SAURON** *data cube.*

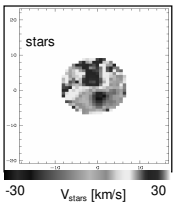


A stellar counterpart of the star-forming ring is also visible [5], with faint flocculent spiral arms [6, 7]. There are also regions of HI, molecular gas, and dust [8]. NGC 7742 is classified as a transition LINER/HII object [9].

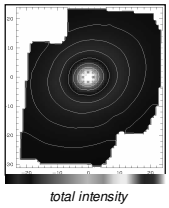


-100 V_{gas} [km/s] 100

Comparison of the stellar and the gas kinematics shows that the gas in the ring counter-rotates with respect to the stellar component, suggesting a merger or accretion event.

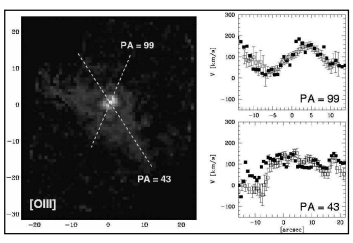


-30 V_{stars} [km/s] 30



total intensity

NGC 5813 is a bright field E1-2 galaxy located in the Virgo-Libra Cloud (M_B=-20.99 [10]). It contains a weak unresolved radio continuum source (3.6 cm [11] and 6 cm [12]) and LINER emission-line ratios [9]. HST imaging shows dust filaments inside the decoupled core visible in the stellar kinematics [13], and narrow-band imaging reveals an elongated ionized gas distribution [14].



The kinematics of the [OIII] emission derived from our **SAURON** *observations resembles that of Hα+[NII] measured by Caon et al. [14] using long-slit spectroscopy. The complex filamentary structure is most likely not in equilibrium with the potential of the galaxy.*

Conclusion

Traditional studies of the internal kinematics and line strength distributions of galaxies relied on long-slit spectroscopy along at most a few position angles. Integral-field maps clearly show that this is insufficient to unravel the rich internal kinematics of spheroids. We built **SAURON** to overcome these limitations.

Preliminary results show that early-type galaxies display a diversity of line-strength distributions and kinematical structures much richer then previously assumed. We have shown here specific examples of minor axis rotation, counter-rotating disks, and complex filamentary structure.

The **SAURON** maps, together with high spatial resolution data from OASIS and HST, enable detailed measurements of individual objects, which will be used for modeling by means of Schwarzschild's orbit superposition method [15]. This will provide much needed insights into the fundamental properties of early-type galaxies and bulges.

References

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