On the Velocity Field and the 3D Structure of the Galactic Soccer Ball Abell 43

Thomas Rauch\textsuperscript{1}, Klaus Werner\textsuperscript{1}, Barbara Ercolano\textsuperscript{2}, Joachim Köppen\textsuperscript{3}

\textsuperscript{1}Institut für Astronomie und Astrophysik, Universität Tübingen, Germany
\textsuperscript{2}Department of Physics and Astronomy, UCL, United Kingdom
\textsuperscript{3}Observatoire de Strasbourg, France

galactic soccer ball Abell 43

Subjective image interpretations of different observers range from "radial filaments" over "soap bubbles" to "pentagons like a (soccer) football's seams". However, instabilities in the nebula's surface are prominent. The most likely explanation might be that the old, slow AGB wind matter is swept up to a thin shell by the fast central star wind. While the invisible inner, high-pressure bubble is expanding back into the history of stellar evolution – but, more importantly, provide even a possibility to investigate the chemical evolution of our Galaxy because most of the nuclear processed material goes back into the interstellar medium via PN.

The recent developments in observation techniques and a new three-dimensional photoionization code MOCASSIN (Ercolano et al. 2003) enable us to analyze PNe properties precisely by the construction of consistent models of PNe and CSs. In addition to PNe imaging and spectroscopy, detailed information about the velocity field within the PNe is a pre-requisite to employ de-projection techniques in modeling the physical structure of the PNe.

Fig. 1. [O III] λ 5007 Å image (FOV 90' x 90') of the PN A 43 (exposure time 48 min) obtained with the Danish 1.54m telescope and DFOSC (La Silla, Chile). The white squares indicate the selected CES aperture (2' x 2') positions.

Fig. 2. Velocity measurements from [O III] λ 5007 Å. The system velocity of 79.4 km/sec (± 5 km/sec) is subtracted. The aperture numbers on the left side correspond to the positions given in Fig. 1.

On the 3D Structure of A 43

Although it appears likely that A 43 is an "almost" ideal PN, i.e. with a spherical shell — besides some density variation within the shell, we tried to employ a deprojection technique (Bremer 1995) in order to improve the interpretation of the nebula morphology and to determine the 3D density structure reliably. However, it became clear that another constraint, a "third dimension" in addition to the 2D narrow-band image is necessary. In order to make progress, we performed high-resolution spectroscopy (centered on [O III] λ 5007 Å, resolution 2 km/sec) in July 1999 of the PN A 43 at ESO's 3.6m telescope (La Silla). We obtained 12 CES spectra at different positions (Fig. 1, 2) in the nebula.

Fig. 3. Intensity of [O III] λ 5007 Å in apertures 1 - 6 (see Fig. 1). The horizontal axis shows -50° < Δ RA < +50°. The vertical axis is the differential radial velocity in km/sec (-55 < Δ v < +55).

Results

The CES spectra of A 43 show an expansion velocity of the shell, measured in [O III] λ 5007 Å of up to 60 km/sec (Fig. 2). A 43 has an almost spherical shell with strong density variations (Fig. 1, 3). The spectra allow to construct a "third dimension" (Fig. 3) to construct a 3D density distribution. However, it turned out that 12 positions in the nebula are not sufficient to provide a reliable database for the de-projection method. Since a reliable 3D density distribution is a crucial input for any 3D photoionisation code, a spatially more complete measurement (about ten times more positions) of the radial velocity is necessary.

Acknowledgements

This research was supported by the DLR under grants 50 OR 9705 S and 50 OR 0201.

References

Balick B. 1987, AJ 94, 971

Poster presented at the International Conference on, "Planetary Nebulae as astronomical tools", June 28 — July 2, 2005, Gdańsk, Poland