On the 3D structures of the planetary nebula Abell 43

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The planetary nebula A 43 is called the “Galactic Soccerball” because images remind one of the seams of a soccerball. Geometrically, this is a so-called “truncated icosahedron”. We present an attempt to construct its 3d density structure based on narrow-band imaging and high resolution spectroscopy.
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Abstract

The planetary nebula Abell 43 (PN G036.0+17.6) is called "Galactic Soccerball" because images remind of the seams of a leather ball. Geometrically, this is a so-called "truncated icosahedron". We present an attempt to construct its 3D density structure based on narrow-band imaging and high-resolution spectroscopy. Its central star is a so-called born-again star that experienced a late He-shell flash and is, thus, hydrogen-deficient.

Introduction

Narrow-band images of PNe are 2D projections. The construction of reliable 3D structures that represent the real density structure based on narrow-band imaging and high-resolution spectroscopy in order to construct the structure of A 43.

Images

We have narrow-band images of \[\text{[O\textsc{iii}]}\], \[\text{[N\textsc{ii}]}\], \[\text{He\textsc{ii}}\], \[\text{H\alpha}\], \[\text{Eso / DFOSC}\] as well as narrow-band images of \[\text{He\textsc{ii}}\] and \[\text{H\alpha}\].

Spectra

We have high-resolution spectra centered on \[\text{[O\textsc{iii}]}\] λ5007 Å, \[\text{[N\textsc{ii}]}\] λ6583 Å, \[\text{He\textsc{ii}}\] λ4686 Å, \[\text{H\alpha}\] λ6563 Å. We have also narrow-band images of \[\text{He\textsc{ii}}\] λ4686 Å and \[\text{H\alpha}\] λ6563 Å, obtained with the 3.6 m NTT and EMMI.

Construction of the 3D PN model

Procedure to construct the 3D density structure:

• Construction of a truncated icosahedron (arbitrary circumradius and orientation).

• Construction of a 3D model grid cube and insertion of the truncated icosahedron inside.

• Assumption of a density distribution around the edges of the truncated icosahedron, in order to construct the seams.

• Vertices are loaded three times, edges are loaded twice.

• Minimal constant density inside the shell between the edges.

• Inside the bubble we compute the density based on the mass loss rate of the central star, the velocity of the stellar wind and the elemental abundance of the central star.

Procedure to model the velocity distribution:

• Inside the bubble every grid point has the velocity of the fast wind of the central star.

• Inside the shell every grid point has the expansion velocity of the nebula.

• Outside the bubble every grid point has the velocity of the former slow AGB wind.

The data is computed by a FORTRAN program and visualized via IDL (Interactive Data Language).

Fig. 1. Image of A43, Hα, [OIII] / DFOSC, exposure time: 1882 sec (blue), [NII] / ESO / EMMI, exposure time: 1200 sec (green). [OIII] / ESO / EMMI, exposure time: 120 sec (blue), FOV = 100' × 100'.

Fig. 2. Synthetic density distribution. The density in the region of the vertices is higher (red) than the density in the region of the edges (green).

Fig. 3. Projection of the 3D model. The red squares show locations of the apertures (2' × 2') of our CES observations.

Fig. 4. Synthetic spectrum and observations of the nebula from East to West at ∆DEC = 0 (Fig. 3). In addition, we test the synthetic spectra of a Doppler–broadened line (Fig. 5) by comparing with the observations. Size and position of the apertures (Fig. 3) are like those of the CES spectra. A few synthetic lines look like those of the CES spectra. A few synthetic lines look similar in relation to height, width and position. Nevertheless, the synthetic spectrum is computed without any photoionization model.

Acknowledgments

EF is supported by the Deutsche Forschungsgemeinschaft (DFG) under grant KA 1745/2-1. TR is supported by the German Buergerwehr Center (GBAC) under grant 001390000.

References


http://astro.uni-tuebingen.de/~friederich/A43.html

Fig. 5. Synthetic spectra (red) and CES observations (black, cf. Fig. 3)