Planetary Nebulae As A Probe Of The Local Group Galaxies Evolution

A.Y. Kniazev[1], S.A. Pustilnik[2], E.K. Grebel[3], D.B. Zucker[4], P. Vaisanen[1]

[1] South African Astronomical Observatory, SAR; [2] Special Astrophysical Observatory RAS, Russia; [3] University of Basel, Switzerland; [4] Institute of Astronomy, United Kingdom

Questions?

Find me around

Introduction

The nearest galaxies are an excellent laboratory for studies of galaxy evolution. Their star formation histories can be obtained with the color-magnitude diagram of resolved stars. However, the results are model-dependent and should be compared with other, additional observational data that can be obtained for these galaxies. One such complementary means is a study of Planetary Nebulae (PNe) that can be used simultaneously as age, kinematics, metallicity tracers and a secondary distance indicators. Additionally, the abundances from both HII regions and PNe allow one to derive an approximate enrichment history for a galaxy from intermediate ages to the present day and permit a measurement of the abundances at different locations.

We present below the latest results from our study of PNe and H II regions in some nearby galaxies: a gas-deficient Local Group dwarf spheroidal Fornax galaxy, and two Local Group dwarf irregular galaxies IC 10 and NGC 6822. For most PNe in these galaxies we have obtained element abundances via the classic T_e-method based on the detection of the [OIII] 4363 Å line.

Fornax PN

1. We present the highest signal-to-noise spectroscopy published to date of the only known PN in Fornax. The depth of our data permits us to measure line ratios of the elements not accessible in the earlier studies.
2. We measured the electron temperature, the electron density, and element abundances for He, N, O, Ar, Ne, Fe and S, and derived the properties of the progenitor star.
3. We conclude that the derived oxygen abundance of $12+\log(O/H) = 8.28\pm0.02$, according to our analysis, should be corrected downward by 0.27 ± 0.10 dex due to the self-pollution of oxygen by the PNe progenitor.
4. After this correction the element abundance ratios Ne/O, S/O and Ar/O appear in a good overall accord with the trends seen for H II regions in other galaxies.
5. The central star shows Wolf-Rayet features in its spectrum similar to the PNe in the Sgr dSph.

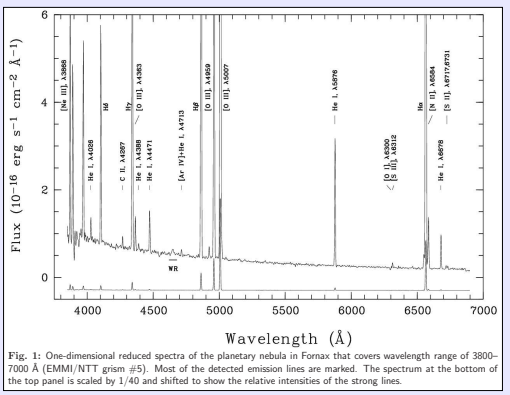

Fig. 1: One-dimensional reduced spectra of the planetary nebula in Fornax that covers wavelength range of 3800–7000 Å (EMMI/NTT grism #5). Most of the detected emission lines are marked. The spectrum at the bottom of the top panel is scaled by 1/40 and shifted to show the relative intensities of the strong lines.

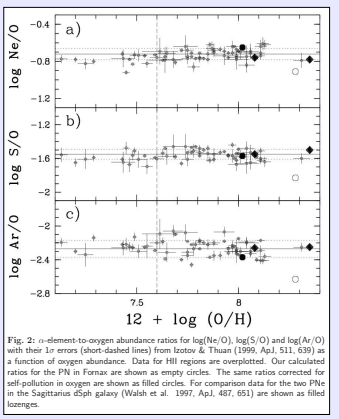

Fig. 2: α-element-to-oxygen abundance ratios for log(Ne/O), log(S/O) and log(Ar/O) with their 1σ errors (short-dashed lines) from Izotov & Thuan (1999, ApJ, 511, 639) as a function of oxygen abundance. Data for HII regions are overplotted. Our calculated ratios for the PN in Fornax are shown as empty circles. The same ratios corrected for self-pollution in oxygen are shown as filled circles. For comparison data for the two PNe in the Sagittarius dSph galaxy (Walsh et al. 1997, ApJ, 487, 651) are shown as filled lozenges.

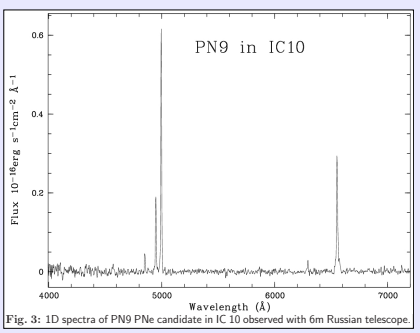

Fig. 3: 1D spectra of PN9 PNe candidate in IC 10 observed with 6m Russian telescope.

PNe in IC 10

1. From the obtained spectral data and the emission line diagnostic diagrams we have found that the brightest candidate PN7 from the list of Magrini et al. (2003, A&A, 407, 51) is not a genuine PN but a close pair of compact HII regions. The absolute magnitude $M_{\lambda5007}$ for PN7 is about 2.5^m brighter than the standard maximum value from the PNe luminosity function expected at the approximate distance of IC 10.
2. We have found that PN candidate PN9 (Magrini et al. 2003) is a true PN, and thus is the first confirmed PN in IC 10.
3. We give an estimate of the age of PN9's progenitor of ~450 Myr, which relates its formation to the period during the strongest SF episode in IC 10 within the last 5 Gyr.
4. With the available PNe candidate data we estimate a PNLF distance to IC 10 of 756^{+30}_{-55} kpc.

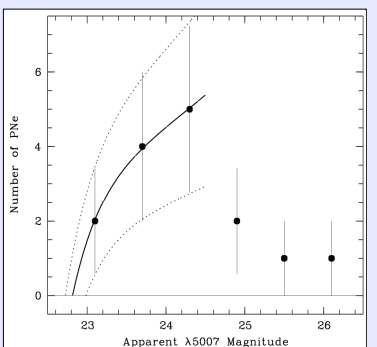

Fig. 4: PNLF for the PN candidates in IC10, excluding PN7. The data have been binned in 0.6^m intervals. The solid curve represents the best-fitting "universal" PNLF. The dotted curves represent the $\pm1\sigma$ error on this fit.

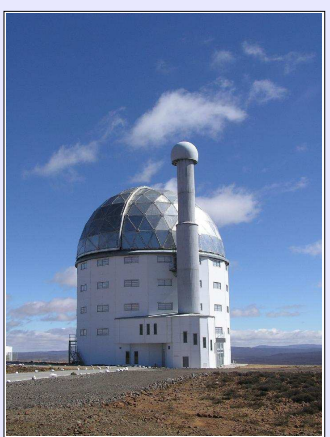

Fig. 5: The Southern African Large Telescope (SALT) is the largest single optical telescope in the southern hemisphere, with a hexagonal mirror array 11 meters across. SALT was completed in 2005 and inaugurated in November 2005.

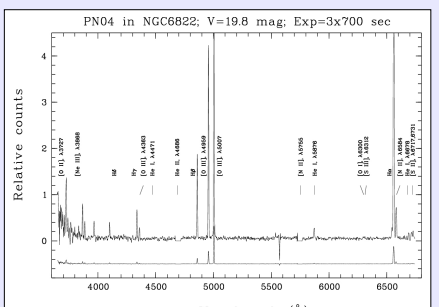

Fig. 6: 1D reduced spectra of the PN4 in the Local Group dwarf irregular galaxy NGC 6822 obtained with the SALT Robert Stobie Spectrograph (RSS). The spectrum was taken with grating 900 l/mm, covers spectral region 3650-6750 Å and has resolution (FWHM) = 5–6 Å. The spectrum at the bottom is scaled by 1/30 and shifted to show the relative intensities of the strong lines.

PNe in NGC 6822

1. We started recently with the SALT Robert Stobie Spectrograph the new observational program "Probing chemical evolution and homogeneity of the nearest dwarf irregular galaxies".
2. Spectra of five PNe candidates (Leisy et al. 2005, A&A, 436, 437) in the Local Group dwarf irregular galaxy NGC 6822 were obtained in the long-slit mode.
3. All observed PNe candidates are true PNe.
4. We measured the electron temperature, the electron density, and element abundances for He, N, O, and Ne or S. Our preliminary calculated average O/H for these PNe is consistent with the average value of $12+\log(O/H)=8.11\pm0.10$, measured by Lee et al. (2006, ApJ, 642, 813) for HII regions.

Last news? Look at http://www.saao.ac.za/~akniazev