Detection of magnetic fields in central stars of planetary nebulae

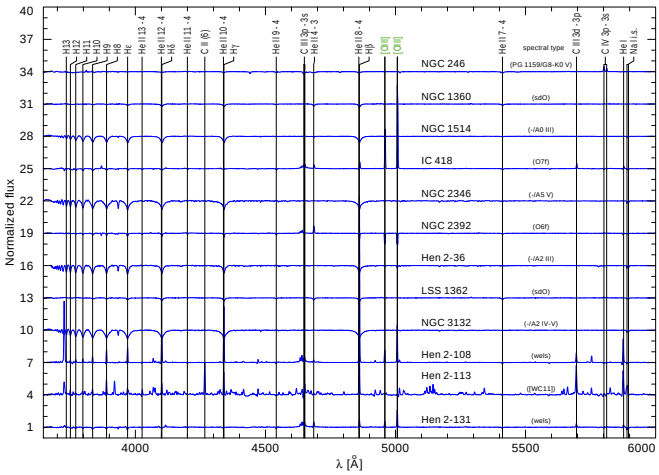
H. Todt[1], M. Steffen[2], S. Hubrig[2], M. Schöller[3], W.-R. Hamann[1], C. Sandin[2], D. Schönberner[2]

[1]University of Potsdam, [2]Leibniz Institute for Astrophysics Potsdam (AIP), [3]ESO Garching

Motivation

- magnetic fields may play essential role in **shaping** planetary nebulae
- so far no detections in CSPNe (Leone et al. 2011, Jordan et al. 2012)
- performing own analysis based on larger sample with higher sensitivity

FORS2 spectropolarimetric observations



Stokes I spectra of our sample of 12 central stars of PNe

- VLT observations in service mode (Oct 2011 - Mar 2012)
- FORS2 with $R \approx 1650$, S/N = 800 ... 2200
- A-type companion dominates central star spectra for NGC 1514, NGC 2346, Hen 2-36, NGC 3132

Magnetic field measurements

- derive mean longitudinal magnetic field $\langle B_z \rangle$ by linear regression:

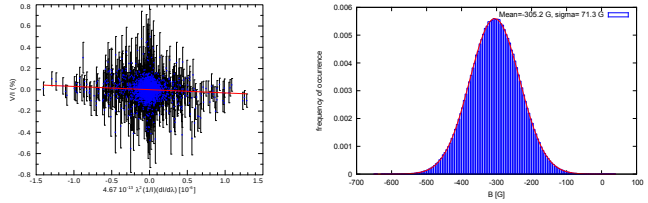
$$\frac{V}{I} = -\frac{g_{\rm eff} e \lambda^2}{4\pi m_e c^2} \frac{1}{I} \frac{{\rm d}I}{{\rm d}\lambda} \langle B_z \rangle$$

- with V Stokes parameter of circular polarization, I intensity of the unpolarized light, $g_{\rm eff}$ effective Landé factor

Analysis

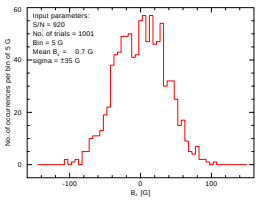
Differences to previous work:

- more robust error estimates
- performing additional statistical tests, e.g. bootstrapping (e.g. Rivinius et al. 2010)



NGC 1514: Regression detection $B_z = -305 \pm 71$ G (left panel) and confirmation by bootstrapping (right panel)

- MC simulation of sensitivity for Hen 2-113:

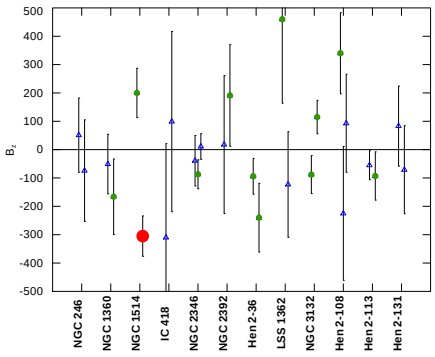


feeding analysis pipeline with 1000 different noise realizations (corresponding to observation, S/N ≈ 920) of PoWR model spectrum (e.g. Hamann & Gräfener 2003) of Hen 2-113 without Zeeman shifts ($B_z = 0$)

→ detection of $B_z > 100$ G in Hen 2-113 at 3σ level

Results

- bootstrapping gives very conservative error estimates



measured magnetic fields for each night, errorbars from boot-strapping, detection (red circle), marginal detections (green circles), non-detections (blue triangles)

→ clear detection only for NGC 1514, where spectrum is contaminated by A-type companion

→ tentative detection in Hen 2-113 if combined with MC simulation

→ detection limit does not rule out magnetic PN shaping

References

Hamann W.-R. & Gräfener G., 2003, A&A, 410, 993
Leone F., Martínez Gonzalez M. J., Corradi R. L. M., Privitera G., Manso Sainz R., 2011, ApJL, 731, L33
Jordan S., Bagnulo S., Werner K. & O'Toole S. J. 2012, A&A, 542, A64
Rivinius T., Szeifert T., Barrera L., Townsend R. H. D., Stefl S., Baade D., 2010, MNRAS, 405, L46