

Ultraviolet emission line imaging of planetary nebulae with GALEX

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Abstract. GALEX (the Galaxy Evolution Explorer) has provided far-UV(1344-1786Å) and near-UV(1771-2831Å) imaging of several Planetary Nebulae (e.g., Bianchi *et al.* 2008, Bianchi 2012), with flux limits ~ 27.5 mag/sq.arcsec for objects in the Medium-dep Imaging Survey (MIS). PNe images in the GALEX broad-band UV filters include flux from both nebular line and continuum emission. We use the GALEX *grism* observing mode to obtain slitless spectral imaging of a sample of PNe with diameters $>1'$, in the near-UV. We show the first data from this program. The grism produces 2D images of the prominent UV nebular emission lines, when such lines dominate the flux. Combined with monochromatic images of diagnostic lines in the optical domain, such data help detect and interpret ionization and shock fronts, especially in faint nebular regions.

Keywords. atlases, planetary nebulae: general, ultraviolet: ISM, ultraviolet: stars, stars: AGB and post-AGB

We are using the GALEX grism observing mode for unraveling the nature of the UV emission seen in GALEX direct images of PNe. In slitless spectroscopy, flux from continuum-emitting extended sources is confused, but for discrete emission lines 2D images are produced along the dispersion direction. For large objects, these overlap in the NUV range where many lines may fall at nearby λ 's, due the $R\sim 100$ grism resolution.

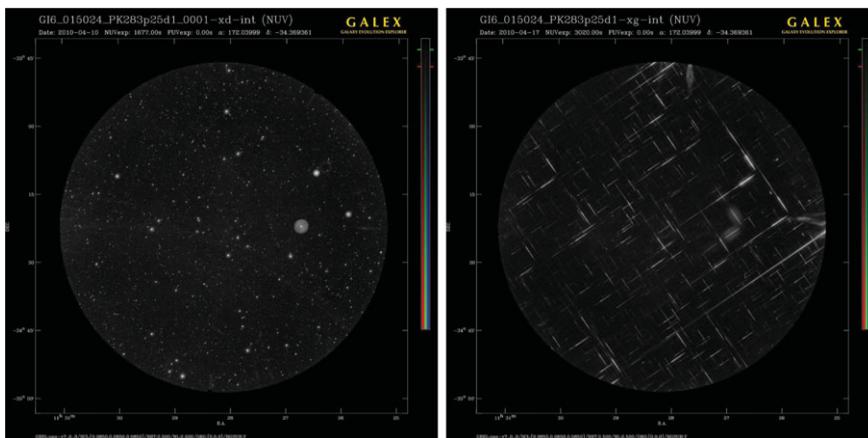


Figure 1. Left: GALEX NUV image of PK283+25 1. Right: co-add of two single NUV grism images taken with different orientations to minimize loss of spectral portions from the overlap of nearby sources in the final extracted spectrum. Note two bright stars NW of the PN: their apparent “halo” is the outer NUV psf tail, showing in these saturated objects. The field of view has a 1.2° diameter

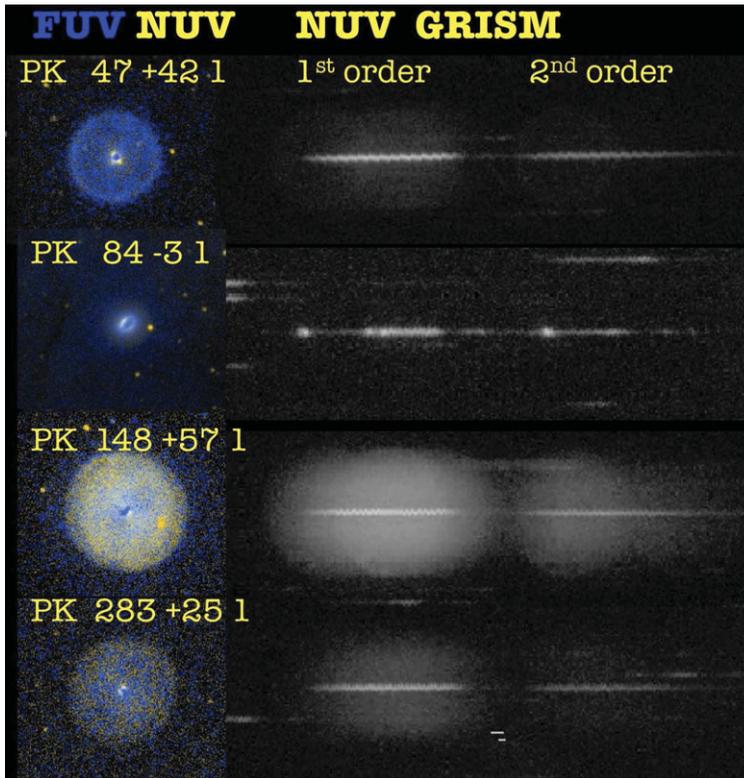


Figure 2. GALEX color-composite imaging (left) of 4 PNe (blue: FUV, yellow: NUV), for which NUV grism data were taken (right). Images are cut to the same size. PK84 -3 1 (NGC 7027) is in an area of blue diffuse cirrus. The grism data show the CSPN continuum, and PN spectral images in several emission lines (often overlapping), with nebular continuum emission possibly in PK 283+25 1 (K 1-22). The NUV range includes CIII]λ1909 at its short-wavelength end.

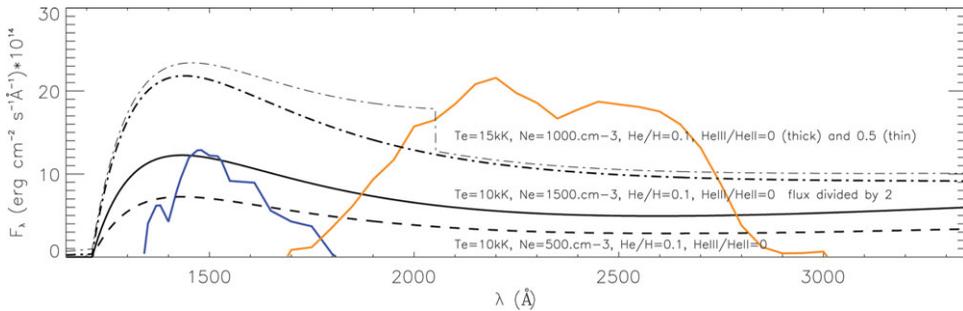


Figure 3. Nebular continuum emission computed for a range of electron temperature (T_e) and density (N_e), He abundance and ionization, for a PN with radius= $60''$ at 10pc. FUV, NUV transmission curves of GALEX imaging are overplotted, on arbitrary scale.

The FUV detector stopped functioning after this program was approved, therefore we lost the capability of imaging CIV.

Acknowledgments Support was provided by NASA grant NNX11AI58G (GALEX G16-15)

References

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 Bianchi, L. & Herald, J. 2008, in A. I. Gomez de Castro & N. Brosh (eds.), *Space Astronomy: The UV Window to the Universe* (Springer)