

The Stellar Wind From the Central Star of NGC 7009

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Abstract. High-resolution 905-1187Å spectra of the central star of NGC 7009 obtained with the FUSE satellite provide new constraints on the mass loss and atmosphere parameters. The most prominent spectral feature is a very strong P-Cygni profile of O VI 1032-1038. The only other wind lines are S VI 933-44 (FUSE) and N V 1238-42 and O V 1371 from IUE spectra. C IV 1548-50 and P V 1118-28 are not present, indicating that the wind is very highly ionized. A lower limit on the mass loss rate ($\dot{M} > 10^{-8} M_{\odot} \text{y}^{-1}$, $v_{\infty} = 2450 \text{ km s}^{-1}$) has been derived from an SEI analysis of these wind lines. Preliminary identification of several photospheric spectral features include several strong Fe VII and O VI lines between 1100 and 1170 Å.

Keywords. planetary nebulae: individual (NGC 7009), ultraviolet: stars, techniques: spectroscopic, space vehicles: FUSE, stars: mass loss

NGC 7009 is a classical elliptical PN with a jet-like structure and low-ionization knots on its major axis. High-excitation emission dominates the inner regions of the nebula, indicating a fast-wind interaction may be important. The current parameters of the hot, H-rich central star ($T_{\text{eff}} = 82,000 \text{ K}$, $\log g = 4.80$, and $y = N(\text{He})/[N(\text{H}) + N(\text{He})] = 0.08$) are from Méndez *et al.* (1988). UV resonance transitions are the best diagnostics of stellar wind parameters.

NGC 7009 was observed by the Far Ultraviolet Spectroscopic Explorer (FUSE) satellite (Moos *et al.* 2000), covering 910-1187 Å at a resolution of $\sim 15 \text{ km s}^{-1}$. These data, plus archival IUE spectra (1150-2000Å), show that only four stellar wind lines are detected in NGC 7009. These are the resonance doublets O VI 1032-38, S VI 933-44, and N V 1238-42, and the excited state transition O V 1371. The lower level of the O V 1371 line is the upper level of the O V resonance line at 629.73 Å. C IV 1548-50 and P V 1118-28 are not present, indicating that the wind is very highly ionized.

Fig. 1 shows part of the FUSE spectrum of NGC 7009. Preliminary identification of photospheric lines include Fe VII, Fe VI, O VI, and possibly F VI 1139.5 (Werner *et al.* 2005). Some features are not yet identified. The line IDs are consistent with the stellar radial velocity of -46 km s^{-1} . The width of the stellar features indicates $v \sin i \sim 100 \text{ km s}^{-1}$. Comparison with the sdO star BD +28 4211 ($T_{\text{eff}} = 82,000 \text{ K}$, $\log g = 6.2$) indicates that Fe VII and O VI, compared with O IV and Fe VI in BD+28 4211, are unexpectedly strong, raising the possibility that T_{eff} may be underestimated in NGC 7009. Non-LTE modelling of the FUV stellar spectrum is in progress.

An SEI analysis of the O VI, O V, N V, and S VI line profiles was made, following the same procedures used by Massa *et al.* (2003). From this analysis the terminal velocity in the wind is $v_{\infty} \sim 2450 \text{ km s}^{-1}$. The wind law parameter β is 0.8. Model profile fits for these four lines are shown in Fig. 2a. Fig. 2b shows $\dot{M}q$ as a function of $w = v/v_{\infty}$, where

