Planetary Nebulae in M31: Abundances, and Comparison with Bright Planetary Nebulae in the LMC

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We have obtained spectra of 28 planetary nebulae in the bulge of M31 using the MOS spectrograph at the Canada-France-Hawaii Telescope. Typically, we observed the [O II]λ3727 to He I λ5876 wavelength region at a resolution of approximately 1.6 Å/pixel. For 19 of the 21 planetary nebulae whose [OIII]λ5007 luminosities are within 1 mag of the peak of the planetary nebula luminosity function, our oxygen abundances are based upon a measured [OIII]λ4363 intensity, so they are based upon a measured electron temperature. The oxygen abundances cover a wide range, 7.85 dex $< 12 + \log(O/H) <$ 9.09 dex, but the mean abundance is surprisingly low, $12 + \log(O/H) = 8.64 \pm 0.32$ dex, i.e., roughly half the solar value (Anders & Grevesse 1989). The distribution of oxygen abundances is shown in Figure 1, where the ordinate indicates the number of planetary nebulae with abundances within ± 0.1 dex of any point on the x-axis. The dashed line indicates the mean abundance, and the dotted lines indicate the $\pm 1\ \sigma$ points. The shape of this abundance distribution seems to indicate that the bulge of M31 does not contain a large population of bright, oxygen-rich planetary nebulae. This is a surprising result, for various population synthesis studies (e.g., Bica et al. 1990) have found a mean stellar metallicity approximately 0.2 dex above solar. This 0.5 dex discrepancy leads one to question whether the mean stellar metallicity is as high as the population synthesis results indicate or if such metal-rich stars produce *bright* planetary nebulae at all. This could be a clue concerning the mechanism responsible for the variation in the number of bright planetary nebulae observed per unit luminosity in different galaxies (e.g., Hui et al. 1993).

It is interesting to compare the properties of the bright planetary nebulae in M31 and the LMC, using the sample of LMC planetary nebulae from Richer & McCall (1995) for comparison. In Figure 2, the [O III]λ5007/Hβ ratios for the planetary nebulae in the two galaxies are plotted as a function of their Hβ luminosity. In the M31 planetary nebula the systematically larger [O III]λ5007/Hβ ratios are immediately striking. Though this might be suspected of being an abundance effect, Figure 3 shows that it arises because the planetary nebulae in the two galaxies have different ionization structures. In Figure 3, we plot the O^{2+}/O^{+} ionic abundance ratio as a function of the Hβ luminosity. Although there are LMC planetary nebulae occupying the range of O^{2+}/O^{+} ratios found in M31, the majority of LMC planetary nebulae are found to have smaller O^{2+}/O^{+} ratios. The disparity in ionization structures between the planetary nebulae in the LMC and M31 is further emphasized in Figure 4, where we plot the He II λ4686/Hβ ratio as a function of the Hβ luminosity. In this diagram, the planetary nebulae in M31 and the LMC occupy almost completely distinct parameter spaces. The simplest interpretation of Figures 3 and 4 is that the bright planetary nebulae in M31 are more optically thin, yet less highly ionized than their counterparts in the LMC. The difference in nebular properties between M31 and the LMC very likely reflects a difference in the nebular density or geometry, but systematic differences in the properties of the central stars may also be involved.

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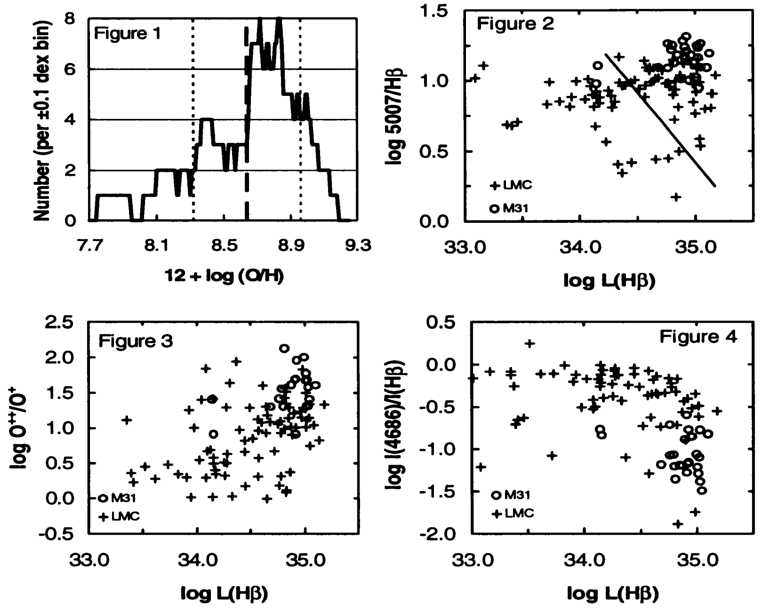

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