High Dispersion Spectra of Planetary Nebulae

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Determinations of the plasma diagnostics and chemical compositions of planetary nebulae require ultimately high dispersion spectra. For objects of high surface brightness the Hamilton Echelle Spectrograph at Lick Observatory is satisfactory for the region 3650–10100Å which involves the 168th to 56th echelle orders. For a slit width of 640 μm amounting to 1.15 arcsec at the Coude focus, the actual spectral resolution (FWHM) is about 0.2Å at 8850Å. The length of the slit is chosen as 4.0 arcsec. Hyung (1994) & Aller (1994) describe the observing procedure. Since the Hamilton echelle was designed primarily for star-like sources, it is not useful for extended low surface brightness PN. The earlier observations were obtained with an 800 $\times$ 800 chip that did not cover the echelle field, so several settings were needed. Later, we used a slower 2048 $\times$ 2048 chip which covered the whole field and was somewhat more efficient at longer wavelengths. The program has been completed and definitive measurements have obtained for NGC 2440, NGC 6543, NGC 6741, NGC 6818, NGC 7026, NGC 7662, and Hu 1-2. All of these PN display particularly rich, interesting spectra. Previously observed and published objects include IC 351, IC 418, IC 2149, IC 4997, NGC 6567, NGC 6572, NGC 6790, NGC 6886, NGC 7009, BD +30 3639, & Hubble 12. NGC 6884 is in press. Additional nebulae which are yet to be discussed are IC 4634, IC 4846, IC 5117, NGC 6210, & NGC 6803.

One of the by-products of the investigation is data for many diagnostic lines which are frequently blended or poorly recorded at lower dispersions. Measurements of such diagnostic lines not only give additional clues to temperatures and densities of PN, but they also provide checks on theoretical calculations of A-values and collision strengths such as those carried out by Keenan and collaborators in Belfast, e.g. for [S II], Keenan et al. (1996). The echelle data are supplemented by other data. Particularly significant are the IUE observations which have been assessed by W. A. Feibelman (see e.g. Feibelman et al. 1994). They play an essential role in determining abundances of the very important elements C, N, and sometimes O. IR data are also very important. Finally abundance determination can be achieved with the aid of theoretical models, which can be used to reproduce observed intensities or derive ionization correction factors, ICFs. Construction of models has often proven difficult from a practical standpoint mainly because of a lack of high resolution direct images. We look forward to adaptive optics, now being developed for ground-based telescopes, to remedy this situation.

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