PLANETARY NEBULAE AS STANDARD CANDLES FOR EXTRAGALACTIC DISTANCES

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ABSTRACT. Although distances to galactic planetary nebulae are typically uncertain by factors near 2, there appears to be an upper limit to the integrated [O III] λ5007 absolute flux for planetary nebulae. This flux, 1.34×10^{-8} ergs/cm^2/sec for a maximally bright planetary nebula at a distance of 1 kpc, can be used as a distance indicator when a sufficient number of planetaries have been identified in an external galaxy. Or one may compute the upper limit to the distance for galactic planetary nebulae based on this calibration.

The original work by Jacoby and Lesser (1982, *A.J.*, 86, 185) has been improved using CCD photometry and updated distances for Local Group galaxies, reducing the calibrator dispersion from 16% to 9%. Considering that the calibrators include ellipticals (NGC 205, NGC 185, M32), a large spiral (M31), and irregulars (LMC, SMC) have a considerable range in metallicity and galaxy luminosity, this small dispersion suggests that planetary nebulae may be excellent standard candles for all Hubble types, and can be identified easily to distances exceeding 10 Mpc. Jacoby, Ford, Booth, and Ciradullo (1987, *Bull. AAS*, 19, 712) derive the distance to M81 using this technique.

Kaler (1978, *Ap. J.*, 220, 887) alludes to the upper brightness limit for the [O III] line. As λ5007 is the principal forbidden line, and the ratios of the important cooling atoms to oxygen remain generally constant, and because forbidden lines are the dominant nebular coolants, an upper limit to the central UV flux implies a more or less constant upper limit to the [O III] flux. Evolutionary paths for central stars imply this observational upper limit: extremely massive central stars pass through the maximum UV flux region too quickly to be important, yet low mass stars have a low UV flux. The balance between lifetime in the region and the frequency of higher mass central stars defines a narrow observational window.

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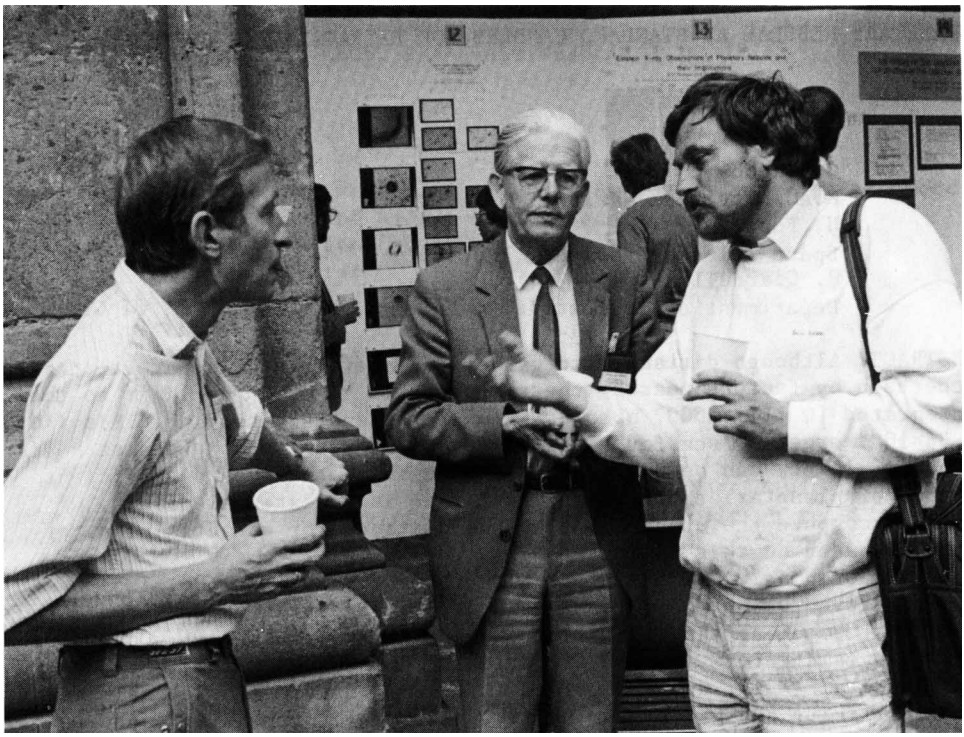

Detlef Schönberner, Volker Weidemann and Rolf Kudritzki.

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