PLANETARY NEBULAE: THEIR EVOLUTION AND ROLE IN THE UNIVERSE
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Orientation Effects in Bipolar Planetary Nebulae

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Abstract. Using a sample of 29 bipolar Planetary Nebulae (BPNe) we show correlations between the luminosity and SED shape with the inclination to the line of sight of the objects polar axes. The presence of an equatorial "doughnut" of material around the central object can explain both these correlations and also and the bipolar shape.

1. Intro and Results

The use of the equatorial "doughnut" model to explain the shape of bipolar nebulae leads to some qualitative predictions: There should be a dependence of the luminosity and shape of the spectral energy distribution (SED) on inclination (i), and this dependence should follow a cosine(i) law for a random distribution of polar axes on the sky. The objects that are viewed near pole-on can have higher apparent luminosities than their central objects because of added reprocessed radiation from the "doughnut". The observed excess luminosity for the low-i objects is compensated by the underestimated luminosity of the high-i objects.

We have computed the luminosities for 29 objects in three bands: BVR or visual, JHK or NIR, and IRAS or FIR, using published data. When plotting the ratio of these three as fractions of the total luminosity against the inclination in Fig.1, we find that both the visual and NIR luminosity fractions are anti-correlated with the inclination, but that the FIR fraction positively correlates. This is expected from the "doughnut" model for bipolar nebulae: less is visible to the observer of the visual and NIR flux but more of the FIR flux as the doughnut comes between observer and central object.

For the few objects with known distances, we list in Table 1 the luminosities for high and low inclination objects. The predicted behaviour is reflected in the fact that all high inclination objects have low luminosities, but the two low inclination nebulae have high luminosity. We have 4 objects in the inclination range 0-30, 11 in the range 30-60, and 14 above 60, so qualitatively the numbers are correct. Small numbers, but at least indicative.

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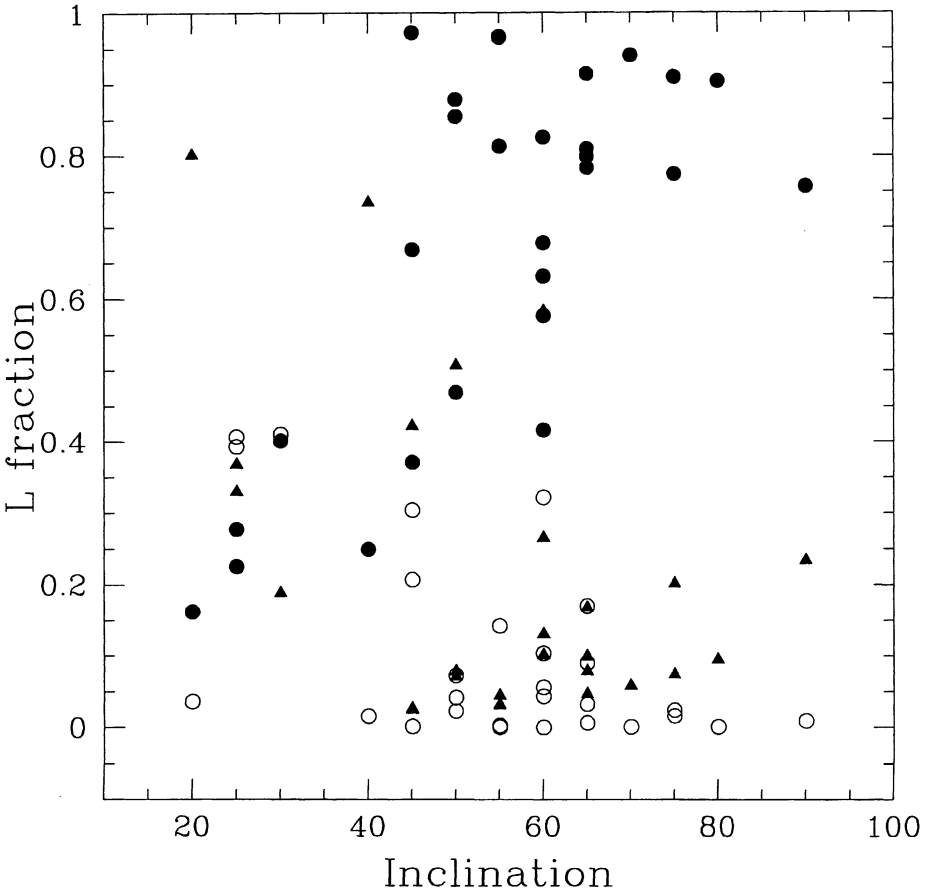

Figure 1. The visual (o), NIR (filled triangles), and FIR (filled circles) luminosity fractions plotted against the inclination of the nebulae. Note the positive correlation with inclination of the FIR data.

Table 1. Luminosities for objects with known distances; differences between high and low inclination nebulae

High i				Low i			
Object	i	d(kpc)	$L_\odot$	Object	i	d(kpc)	$L_\odot$
Sa2–237	70	.1	340	R Aqr	20	0.2	2800
M2–9	75	0.64	553	BI Cru	40	1.8	3400
He2–104	50	1.0	205	-	-	-	-
He2–111	70	2.8	440	-	-	-	-
M1–16	70	1.8	194	-	-	-	-

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