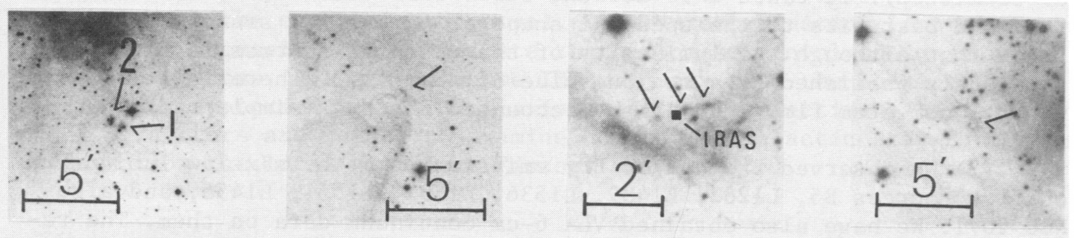

Figure 1a NGC 1499-1 and 2 | Figure 1b M 42-3 | Figure 1c NGC 2264-1 | Figure 1d NGC 2264-2

Fig. 1

We are extending our searches by this technique to other star-forming regions. We are also continuing with follow-up observations to confirm the HH nature of the rest of the objects in Table I.

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IR LINE AND CONTINUUM EMISSION FROM BIPOLAR OUTFLOW SOURCES

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Most of our understanding of BPF's is based on observations of the neutral and ionized gas in bright, high luminosity sources. Data on low luminosity ($L \lesssim 30\ L_\odot$) objects has now become more available (e.g. Frerking and Langer, Astrophys. J. 256, 523, 1982) permitting a test of models at this end of the luminosity range. We have performed a series of multi-wavelength observations, emphasizing low luminosity objects.

(1) First, we have obtained revised values of L using the IRAS data base at the NRL IRAS Data Reduction Center, and we have produced a revised plot of MV(CO) vs. L. (Mozurkewich, Schwartz and Smith, Astrophys.

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J. submitted). It takes into account color corrections to the IRAS filters and best fits to the spectral shape of 44 outflow sources, and shows that although the luminosity of the obscured sources is larger than previously published by a median value of about 1.5, there is still more neutral momentum flow than can be accounted for by a simple radiation model.

(2) We observed Brα and/or Brγ emission from the six low luminosity outflow sources B5, L1262, L1489, L1536, L1582, L1551, L1455, and also NGC 2071. We have also obtained VLA 6-cm continuum data on them. The results, presented in Smith, Fischer, Geballe and Schwartz (Astrophys. J. submitted), are consistent with emission from ionized winds like those seen in more luminous objects. The results are plotted in Figure 1 as log Brα versus log L, with data on higher luminosity objects taken from Persson *et al.* (Astrophys. J. 286, 289, 1984). The curve shows that an approximately linear fit can be made over three orders-of-magnitude in L. A linear expression can be derived by assuming that the wind is radiativelly driven, and by using an expression for the line intensity that relates it to the mass-loss rate as described in Krolik and Smith (Astrophys. J. 249, 628, 1981). The expression for the Brα luminosity is

$$L(\mathrm{Br}\alpha)_{\mathrm{watts}} = 2\times10^{-7} L_*^{4/3} \frac{\mathrm{ergs}\ V^{-7/3}}{\mathrm{sec}} \frac{\mathrm{cm}}{\mathrm{sec}} . \qquad (1)$$

This curve is also plotted in Figure 1, with a hatched area corresponding to the range in observed velocities. The very good fit to the data indicates that the ionized gas can be radiatively driven, although the neutral gas usually cannot be so powered. This conclusion was reached qualitatively by Persson *et al.* and others.

(3) There are at least three objects (NGC 2071, L1551 IRS5, and L1455) that are notable in that they do NOT seem to fit the above model. In all cases these sources have strong radio continuum and CO wings but do not show any evidence for Brα emission. The absence of Brα might be due to large extinction. Obscuration by a disk of size $\sim 10^{16}$ cm (c.f. Pudritz Astrophys. J. 293, 216, 1985) would require $\sim 1\ M_\odot$ of material only somewhat less than expected from the Pudritz model. We note that the CO lobes in these sources are well separated, as expected for an edge-on disk. An alternate possibility is that the strong wind has temporarily stopped. Caution should therefore be used when citing L1551 and NGC 2071 as prototypes of outflows.

(4) We have observed a number of IR active galaxies in the lines of Brγ and H_2 1-0 S(1) emission at UKIRT, KPNO and the AAO. Fischer, Simon, Smith, Geballe and Storey (Astrophys. J. 1986 submitted) discuss the data in detail. We plot the Brγ results vs. L in Figure 2 (an expanded version of Figure 1), expressing the Brγ in terms of Brα via the relation I(Brα) = 1.25×I(Brγ) derived for an optically thick wind (Simon *et al.* 1983). The luminosities of the galaxies are determined from IRAS PSC measurements. In the figure we plot Eq. (1) ($P \propto P^{4/3}$), and also show a linear extrapolation of the emission from luminous sources ($P \propto L$). Corrections for extinction of the line, or for IR luminosity arising in extended regions outside the Brγ beam, will tend to move the points upward. The estimated error bars in the figure reflect this. Even consid-

ering these assumptions and uncertainties the galaxy points are reasonably close to the extrapolated curves. The IR recombination line measurements by themselves thus indicate that processes involved in star-formation regions, even those whose IMF may vary from the local value, are able to approximate the IR emission seen in some active galaxies. Other parameters are needed to examine how active galactic star-formation differs from the local kind (see Fischer *et al.* 1986).

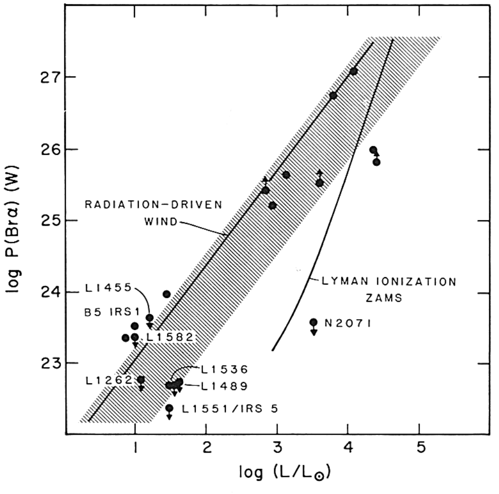

Fig. 1

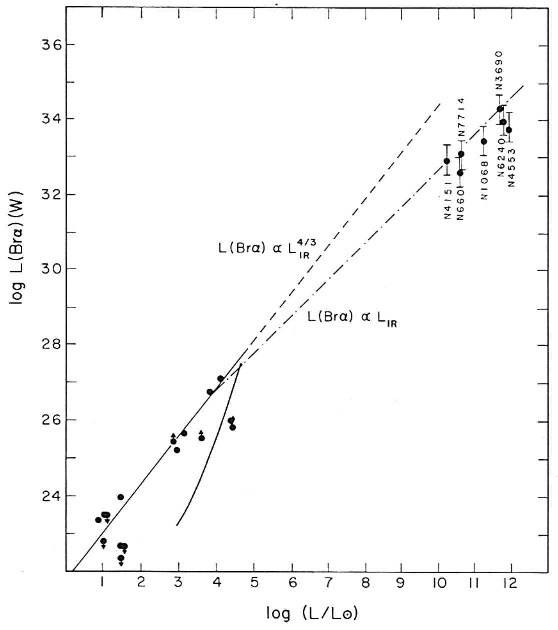

Fig. 2

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