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PARSEC-SCALE OUTFLOWS FROM INTERMEDIATE-MASS STARS

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While there are many large-scale outflows which are known to be driven by low-mass sources, there are few such outflows associated with higher mass sources. In this survey, parsec-scale outflows were found from five intermediate-mass sources. These show similar length, morphology, dynamical timescales, and collimation as parsec-scale outflows from low-mass sources. Many of these outflows also appear to have blown out of the parent cloud, suggesting that the total length of the outflow is greater than what is optically observable.

Here we will only discuss one of these outflows, LkHα 198. This outflow and the others not discussed here (1548C27 IRS1, IRAS 19395+2313, LkHα 233 and LkHα 234) are discussed in detail in McGroarty & Ray (2003). A number of new objects were found in the outflow driven by LkHα 198, which is shown in Figure 1. All the newly discovered HH objects have been temporarily assigned HH numbers of 800 and above. HH 801 is 0.9 pc from LkHα 198 and is at a position angle (PA) of 340° with respect to the star. It appears to be the western wing of a bowshock, the rest of which is optically obscured. HH 802 is 1.43 pc from LkHα 198 at a PA of 160° and consists of a number of individual knots and shocks. Both of these objects are directly aligned with the previously known outflow close to the source (HH 164). The total length of this outflow is 2.3 pc.

Although this is the shortest of the newly discovered parsec-scale outflows, it clearly demonstrates some of the morphological trends that are also seen in the other four outflows. The first of these trends is that the more distant objects in the outflows are generally larger than those closer to the source and this is clearly seen in this outflow. Secondly, there is an increasingly larger distance between consecutive objects with distance from the source. For example, the distance between HH 461 and HH 802 is greater by a factor of 13 than the distance between HH 164 and HH 461. The final morphological trend is that the more distant objects are more complex. This is demonstrated well by HH 802 which consists of nine knots and shocks stretching over a distance of 2′ as opposed to a single knot like HH 461. These three morphological trends are also characteristic of large-scale outflows from low-mass sources.

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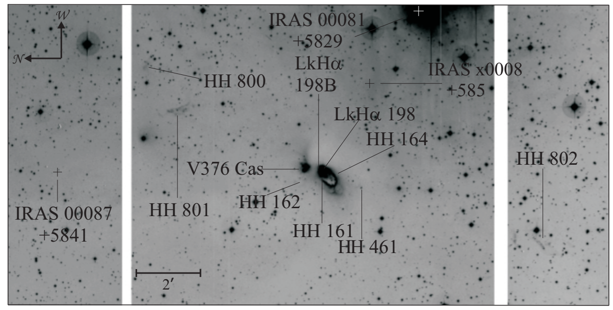

Fig. 1. Mosaic of outflow from LkHα 198.

The outflows discovered here range from 2.3 to 8 pc in length, which is comparable to the length of large-scale outflows from low-mass sources. When the outflow "blows" out of the cloud it is then propagating through a medium of lower density and so any shocks generated will be very faint at optical wavelengths. It is then expected that the optically observable length of the outflow is determined by the size of the parent cloud. As the size of the parent clouds are similar for both low- and intermediate-mass sources, we expect that the optically observable lengths of the outflows will be similar.

The dynamical timescales of these outflows are of the order of a few times 10^4 years. These outflows are then a few tenths of the evolutionary timescale of the source which is $\sim 10^5$ years. From this, the mass-loss history of the source can be extrapolated for a significant portion of the accretion phase of the source. These dynamical timescales are also comparable to those of low-mass outflows.

Turbulence is constantly injected into molecular clouds and large-scale outflows are a possible mechanism for this process. However, the degree of collimation of these outflows is of the order of 5° so it is more likely that the outflows found here would tunnel through the cloud rather than supply any appreciable amount of turbulence to it. Also, as mentioned above, many of these outflows have blown out of the parent cloud, so any turbulence they are supplying would be to the ISM.

REFERENCES

McGroarty, F., & Ray, T. 2003, in preparation