used to evaluate more clearly the role of enhancement in various *in vivo* settings. Regardless, however, of whether or not the effects of enhancement are of major significance in HIV pathogenesis, the possibility must be eliminated that they would be induced before testing any form of vaccination or immunotherapy against HIV. □

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ASTROPHYSICS

Stellar winds and jets resolved

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MANY, perhaps most, stars blow off large quantities of gas in early and late stages of evolution for reasons that are poorly understood. In addition to the dramatic explosions of supernovae, stellar winds are observed that are 10^6 – 10^{10} times as intense as the Sun's, and these can have profound effects on the evolution of the star and of the surrounding interstellar gas. Two new reports indicate the importance of spatially-resolved observations of stellar winds in elucidating the mechanisms of mass ejection. On page 449 of this issue¹, Moran *et al.* describe their radio-interferometric observations, using the MERLIN array run from Jodrell Bank, of an unusually active 'Wolf-Rayet' star. This is expelling material at a rate considerably greater than most stars in its class and so presents a challenge to theorists. And Reipurth recently presented² highly resolved CCD (charge-coupled device) images of a remarkable high-velocity jet — a so-called Herbig-Haro object — ejected far into space by a star that has only just formed.

Moran *et al.*¹ studied a Wolf-Rayet (WR) star, AS431, that is one of the more luminous stellar objects in our Galaxy. Such stars are remarkable for the rapid rate at which they eject material, resulting in substantial reduction in the stellar mass over the astronomically short times of 10^4 – 10^5 years³. Radiation pressure is undoubtedly responsible for the mass ejection, but present theories cannot account well for the extreme efficiency of ejection that observations of thermal radio emission indicate. Such observations can determine mass-loss rates very accurately⁴. However, some WR stars, including AS431, radiate non-thermal radio emission, the origins of which are not clear, so that mass-loss rates cannot be accurately derived for these objects⁵.

The radio-interferometric observations of Moran *et al.*, with a spatial resolution of 0.15 arcseconds, show that AS431 is a double object. The southern component, according to astrometry, corresponds to an optical star. This, Moran *et al.* argue, is

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11. Desrosiers, R.C. *et al.* *Proc. natn. Acad. Sci. U.S.A.* (in the press).
12. Gibbs, C.J. *et al.* *V Int. Conf. AIDS Abstr. C.Th.C.O.46* (1989).

the source of the wind radiating thermal emission. If this interpretation is correct, the derived mass-loss rate is several times the typical rate found for WR stars, making AS431 an extreme example that is particularly challenging to radiation-pressure theories. Moran *et al.* suggest a solution to the puzzle of the non-thermal

Jets represent remarkably efficient conversion of source energy into kinetic energy. The morphology, in these cases showing a series of equally spaced 'knots' of bright emission, remains similar at many scales, from stellar jets (Herbig-Haro objects), such as HH7–11 shown above and HH111 discussed by Reipurth, to galactic jets such as in M87 (below). The arrows indicate the infrared sources of the jets; the mark in the top left is a foreground star. (From ref. 7.)

emission by associating it with the second source. They speculate that high-velocity shocks (moving faster than 700 km s^{-1}) between the WR wind and the wind of a fainter companion star generate the non-thermal emission⁶.

Reipurth's report² concerns one of the very young stars known to eject substantial amounts of material in strikingly thin, high-velocity jets⁷. The jets are often contained within bipolar flows of molecular gas⁸. The flows are thought to be channelled by a dense cloud or disk around the star, left over after the star formed. The jets are far too thin to be focused by a flat disk, leading to suggestions^{9,10} that magnetic fields along the rotational axis of the system are responsible for confining

the flow. The cause of this mass ejection is not understood at present.

Reipurth studied a remarkably high-velocity jet, HH111, emanating from a young star completely shrouded from view by natal dust and gas. The jet is rendered visible by the interaction of the high-velocity ejecta with the interstellar medium, resulting in shock waves which excite optical emission lines. The emission can be traced out for a projected length of 23,000 astronomical units (1 AU is the radius of Earth's orbit), with a length-to-width ratio of about 30.

The most remarkable features of this object, however, are the bow shocks observed on either side of the infrared source. Simple continuous-flow models¹¹ for jets suggest that they should terminate in a curved bow shock, where the jet runs into the ambient interstellar medium. But in HH111, Reipurth found evidence that there are two bow shocks at each end of the bipolar ejection, as if material had been ejected in separate bursts rather than continuously.

This result is of particular interest because jets and bipolar flows often imply extremely efficient conversion of source energy into outflow kinetic energy⁸. Some pre-main-sequence objects, the FU Orionis variables, vary by one to two orders of magnitude in luminosity¹², have very large mass-ejection rates and, in some cases, exhibit jets and bipolar flows^{13,14}. Reipurth's suggestion is that intense jets arise when the rapid accretion of material from the protostellar disk¹⁵ produces short-lived bursts of energy. This model of accretion-disk-driven jets is strikingly similar to theories of extragalactic radio jets that arise from active galactic nuclei⁹ (see figure), wherein accretion onto a central black hole is the ultimate energy source. We may obtain considerable insight into the (non-relativistic) production of jets from the study of nearby young stars. □

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