Image of the Month - September 1997
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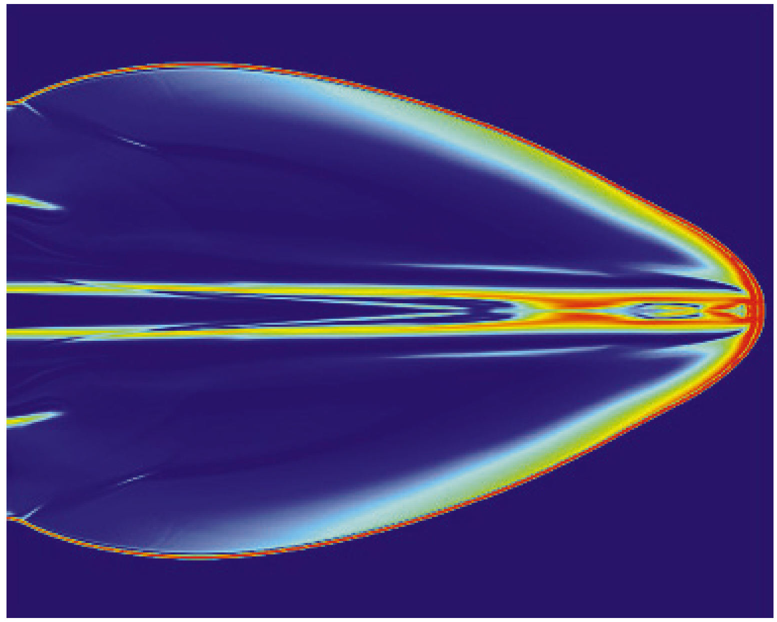
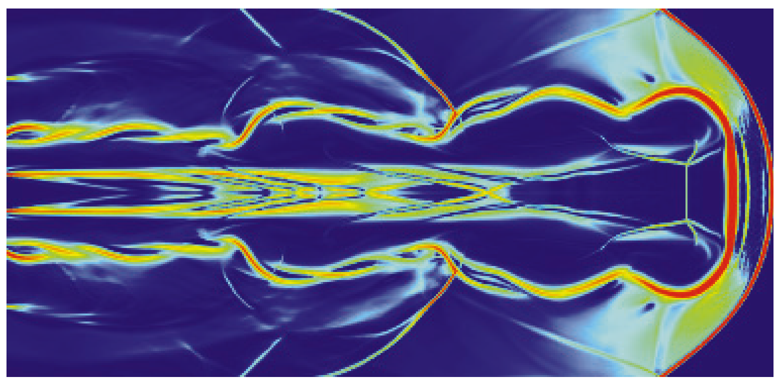
Light-Speed Jets

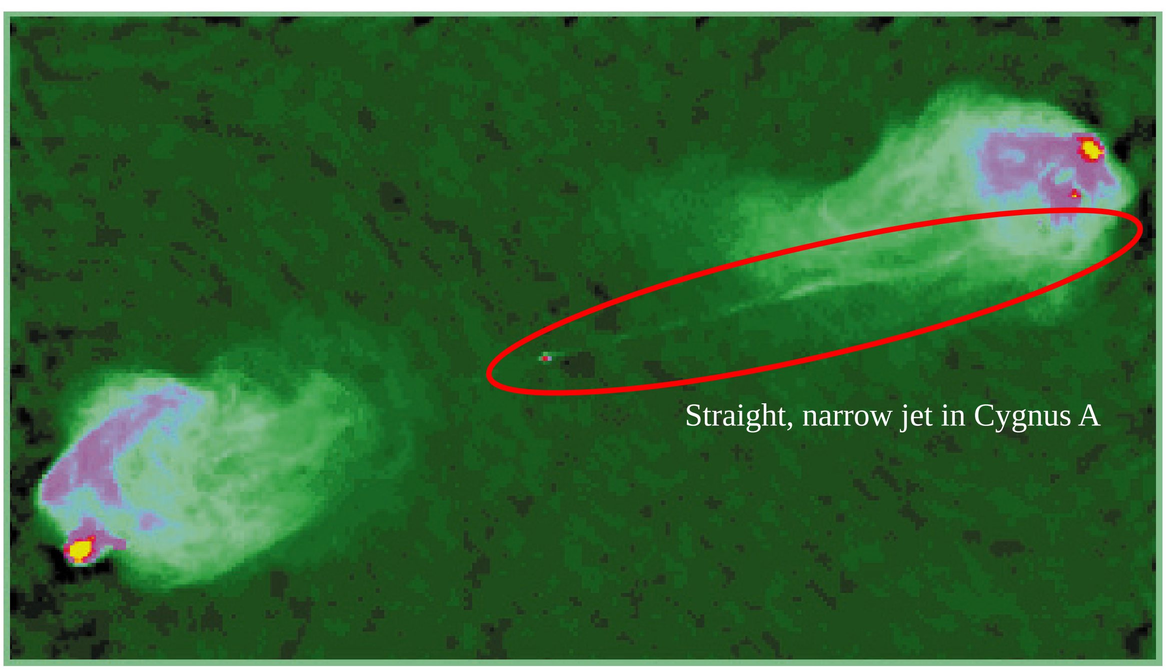




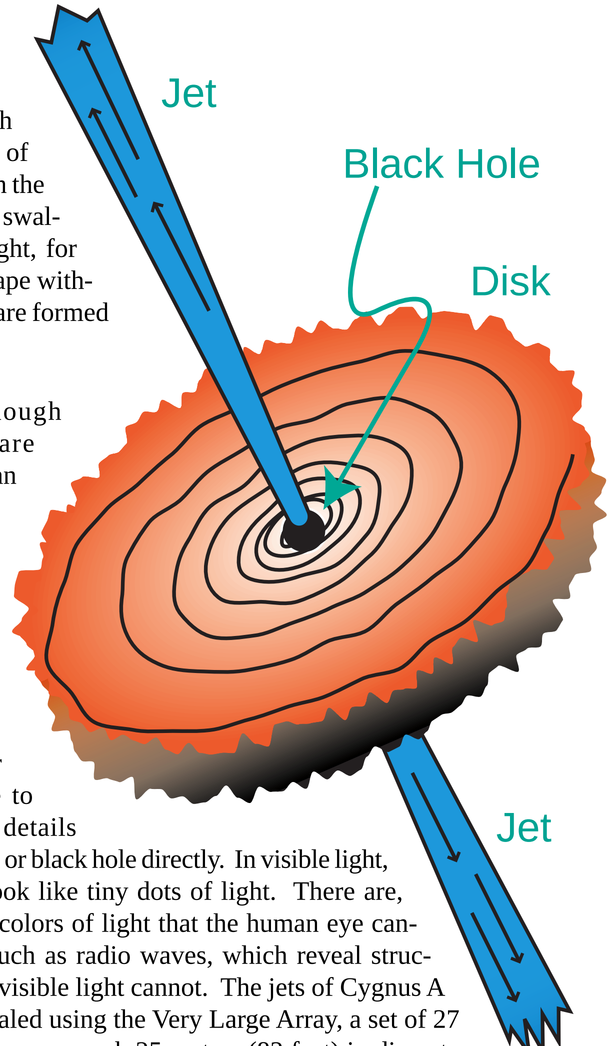
The images at right show *computer simulations* of a jet of gas being blasted into space at nearly the speed of light. In the centers of some galaxies lie *quasars*, objects the size of the Solar System which emit as much energy as an entire galaxy of stars. Most astronomers believe that at the heart of each quasar lies a black hole a billion or so times as massive as our Sun. When astronomers examine some quasars using radio telescopes (such as the VLA described on the other side) they look like the radio galaxy **Cygnus A** shown in the lower picture: on either side of the (invisible) central black hole there are jets of gas shooting out into space, plowing up the surrounding gas and blowing bubbles thousands of light-years across.

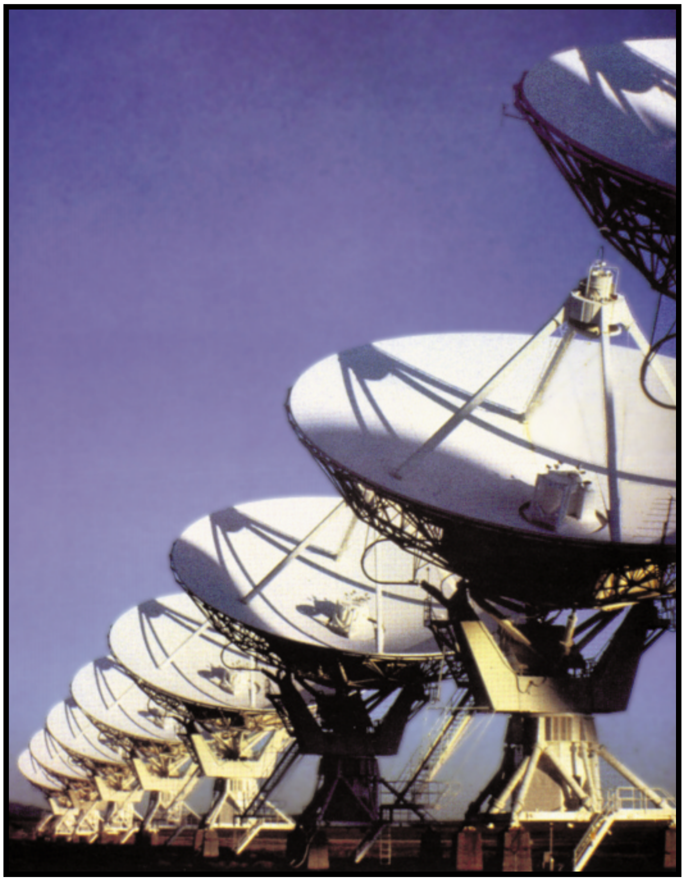
Since we cannot study black holes in any Earthly laboratory, Drs. Philip Hughes of the University of Michigan and Comer Duncan of Bowling Green State University programmed a computer to mimic these jets. The technique is the same as that used by aerospace engineers to study the flow of air over supersonic planes. Cosmic jets are particularly challenging because they flow at nearly the speed of light, so the computer must be "taught" Einstein's Special Theory of Relativity in order to get a correct answer.

In the lower simulation, gas enters from the left "slowly" (only 98% of light speed!) and as a consequence the jet and surrounding material tend to mix (note the wavy boundary between them.) The upper simulation is for a jet travelling at 99.5% the speed of light: it rams through the surrounding gas with no mixing. This upper picture seems a better match to the straight, narrow jets of the real Cygnus A at right, so we are led to believe that its jets are travelling at the higher speed.

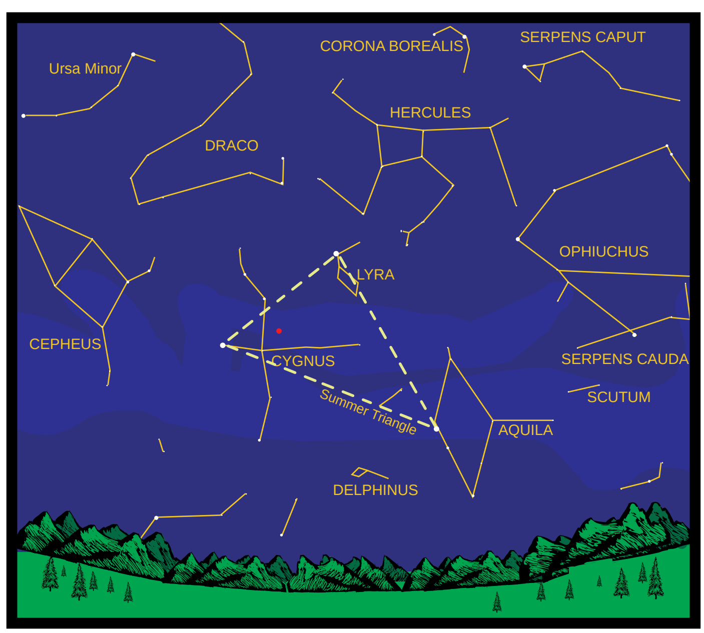


Why are jets such a common feature of our Universe? At right is a cartoon view of the guts of a quasar. Lurking in the very center is a black hole about the size of our Solar System. As the surrounding stars and gas are pulled in by the tremendous gravity of the black hole, they start to swirl, just as bath water does as it approaches the drain. This spinning disk (drawn as orange) of debris flattens out and becomes tremendously hot from friction, glowing with the visible light we identify as a quasar. Not all of the collapsing material is swallowed by the black hole - some of it is expelled at nearly the speed of light, for reasons that are not well understood. The only place for this material to escape without being blocked by the disk is up or down, so two jets (drawn in blue here) are formed in these opposite directions.





Even though quasars are bigger than our Solar System, they are billions of light-years away, so we have never been able to view the details of the disk or black hole directly. In visible light, quasars look like tiny dots of light. There are, however, colors of light that the human eye cannot see, such as radio waves, which reveal structures that visible light cannot. The jets of Cygnus A were revealed using the Very Large Array, a set of 27 radio telescopes, each 25 meters (82 feet) in diameter, spread across a 20 mile stretch of desert near Socorro, New Mexico. In this summer's movie "Contact," Jodie Foster's character discovers signs of alien life using the VLA. In reality the VLA has not yet discovered signs of extraterrestrials, but examining light-speed jets shooting out of massive black holes is nearly as interesting!



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This Image of the Month is produced by José F. Salgado, Gary Bernstein, Philip Hughes, Chris Smith, Beth Brown, and Richard Teske of the University of Michigan, and is funded by a grant from NSF. If you are Michigan science teacher and would like a free subscription, send e-mail or write us at: Department of Astronomy, 830 Dennison Bldg., Ann Arbor, MI 48109.