Mapping Orion's winds

By David F. Salisbury

Published: January 10, 2006

For the past few months, Bob O'Dell has been mapping the winds blowing in the Orion Nebula, the closest stellar nursery similar to the one in which the sun was born.

New data from the Hubble Orion Heritage Program, a major observational effort by the Hubble Space Telescope in 2004 and 2005, have given the Vanderbilt astronomer the information he needs to measure the stellar winds with unprecedented detail, and he reported his early results on Jan. 11 at the annual meeting of the American Astronomical Society in Washington D.C.

"Determining how stellar winds interact with the ambient material in stellar nurseries like Orion is a critical factor in understanding the process of star creation," says O'Dell, distinguished research professor of astrophysics and an international authority on Orion.

All stars, including the sun, give off a stream of particles as they burn. In young, hot stars like those that form the "Trapezium" at the heart of Orion this stream of particles is millions of times more dense and energetic than the solar wind. Newborn stars, which are still shrouded in thick veils of dust and gas, often eject gas and dust from their polar regions in narrow jets, rather than broadcasting them outward in all directions. When these stellar winds impact floating clouds of dust and gas, they produce shock waves that erode and shape the clouds in a fashion similar to the way in which terrestrial winds sculpt sand dunes. When they are strong enough, such shock waves also can compress the free-floating clouds of dust and gas, triggering the formation of new stars.

O'Dell is using these shock waves as celestial "wind socks" to plot the direction of these winds in different parts of the nebula. By back-tracking older, more distant shock waves to their likely points of origin, the astronomer can also get an idea of how long major currents have been flowing.

“When you look closely enough, you see that the nebula is filled with hundreds of visible shock waves,” the astronomer says.

In his analysis, O’Dell has identified three different types of shock waves:

- Bow-shocks are stationary shock waves that are formed by the collision of two steady winds and are excellent indicators of wind direction. They are present near the hottest stars in the center of the nebula where they show winds flowing outward at velocities of thousands of kilometers per second. They are also present in the outer nebula where they are produced by low velocity stellar winds of tens of kilometers per second.
- Jet-driven shocks are produced when narrow streams of gas and particles traveling at hundreds of kilometers per second pass through gas that is relatively stationary. There are many shockwaves of this type in the nebula that are produced by jets of material ejected by newly formed stars.
- Warped shocks are jet-driven shocks located in areas where the ambient gas is not stationary but is moving in a cross current. This bends the jets and shocks into bow-like shapes.

Using these markers, the astronomer has mapped the outflow from two of the three regions of star formation in the nebula. Both of these regions, labeled BN-KL and Orion-South, are located behind the glowing region of the nebula where the light from the central stars ionizes the outer layers of the parent molecular cloud. The specific objects that are producing these winds in the two regions are not visible to optical telescopes but they stand out as hot spots in infrared images.

By tracking back the farthest shockwaves produced by these outflows, O’Dell has established that the winds blowing from BN-KL have been doing so for 900 to 1,100 years, while those from Orion-South have been going on for 200 to 1,500 years.

These observations were made during 104 orbits of the Hubble and provide the most comprehensive picture ever obtained of the Orion Nebula. The data will be combined with other Hubble and ground-based telescope observations to create a widely available archive for research scientists interested in this region, in addition to acting as a base for a detailed study that should provide new insights into the conditions required for creating stars like the sun.