

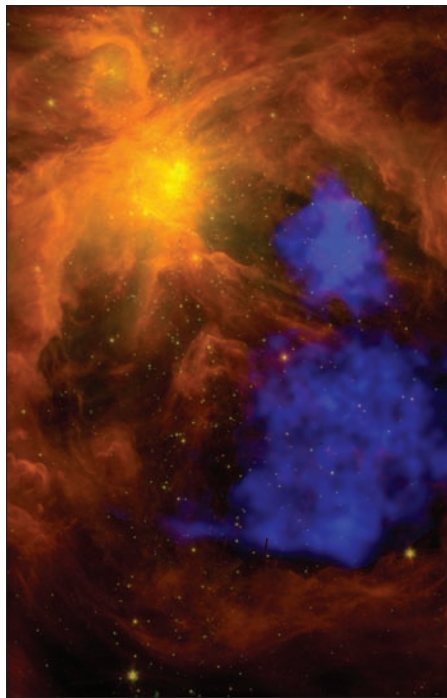
Hot plasma fills the Orion nebula

Observations with the XMM-Newton satellite have revealed soft X-ray emission from an extended region in the Orion nebula. The most massive stars in the heart of the nebula are probably at the origin of this million-degree plasma flowing through it.

The Orion nebula (Messier 42), is more than a thousand light-years away, but is visible to the naked eye. It is the most spectacular star-forming region in the northern sky. The nebula hosts the Trapezium group of four recently formed very massive stars – seen by eye as a single star called Θ Orionis – which illuminate and ionize the surrounding gas.

A team of astronomers led by Manuel Güdel from the Paul Scherrer Institute in Switzerland has discovered that a hot plasma pervades the nebula. The extended plasma emission, which reaches a temperature of about 2 million degrees, was observed with the relatively wide-field camera of the European X-ray Multi-Mirror satellite (XMM-Newton).

In the absence of a supernova bubble in this very young nebula, which is about 3 million years old, the only source of energy available to heat the gas is the fast wind from the Trapezium stars. The brightest star in the group is about 40 times more massive than the Sun and generates a wind of plasma with a speed up to 1650 km/s. The violent collision between this wind and the surrounding dense gas heats the plasma to millions of degrees, but only about a ten-thousandth of the wind's kinetic energy is needed to account for the X-ray luminosity of the hot plasma.



Spitzer image of the Orion nebula in the infrared overlaid with the distribution of hot gas observed by XMM-Newton in blue. The Trapezium stars are located in the brightest region in the upper-left part of the image. (Courtesy AAAS/Science/ESA XMM-Newton and NASA Spitzer data.)

Further calculations by Güdel and colleagues show that the hot X-ray plasma is approximately in pressure equilibrium with the ambient ionized gas, because although it is cooler the latter compensates the pressure

by being much denser. This equilibrium could explain the presence of the hot gas in a cavity in the nebula: the hot gas would be channelled by the cooler, denser structures and slowly flow into the cavity.

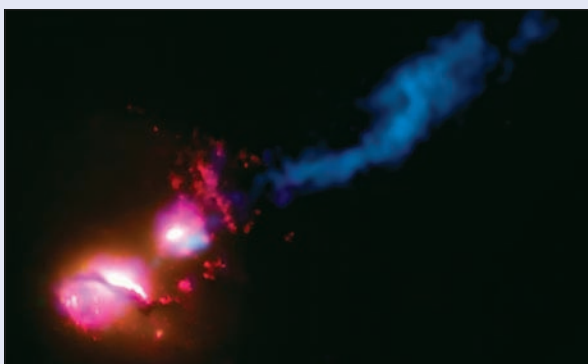
This is not yet the end of the journey, however. Güdel and colleagues further speculate that the hot gas could continue its flow out of the cavity into the nearby Eridanus superbubble, like a river flowing out of a lake into the sea. This giant bubble is 400 light-years wide and extends over 20 degrees of the sky. The wind-shocked gas from the Trapezium stars would thus slowly replenish the Eridanus superbubble, which was formed by supernova explosions from previous generations of massive stars. The team plans further observations to test this scenario, which could also explain how the observed radioactive aluminium-26 could have migrated from the Orion nebula into this superbubble (*CERN Courier* January/February 2006 p10).

If the proposed scenario is correct, it means that the gas in our galaxy is not only enriched by heavy elements – such as carbon, oxygen, nitrogen or iron – from sudden supernova explosions. It could also be gently enriched over millions of years by the continuous stellar wind of massive stars that leaks out of star-forming regions into the interstellar medium.

Further reading

M Güdel *et al.* 2007 *Science Express*
DOI: 10.1126/science.1149926.

Picture of the month



This composite image shows for the first time a jet from a supermassive black hole striking the edge of a companion galaxy in the system known as 3C 321. Supermassive black holes at the centre of galaxies can produce a pair of powerful plasma jets that are ejected in opposite directions (*CERN Courier* July/August 2006 p10).

The peculiarity of 3C 321 is that the jet (blue) from the main galaxy at the lower left of the image hits a companion galaxy only 20 000 light-years away and gets deflected by this interaction. The image combines X-ray data from Chandra (purple), ultraviolet and optical data from Hubble (red and orange), and radio emission from the Very Large Array (VLA) and MERLIN (blue). (Courtesy X-ray: NASA/CXC/CfA/D Evans *et al.*; optical/UV: NASA/STScI; radio: NSF/VLA/CfA/D Evans *et al.*, STFC/JBO/MERLIN.)