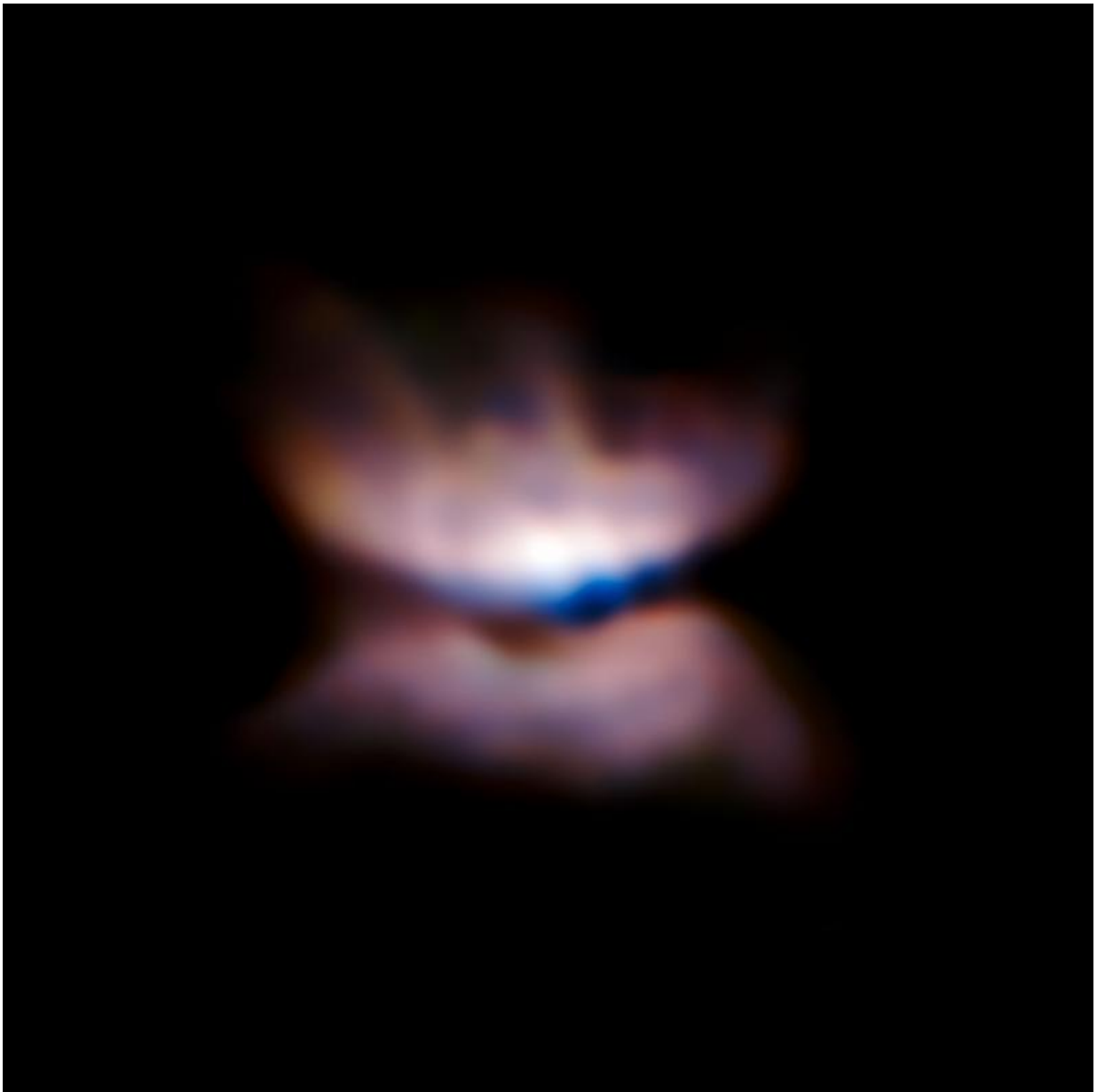


A celestial butterfly emerges from its dusty cocoon

June 10 2015



Some of the sharpest images ever made with ESO's Very Large Telescope have for the first time revealed what appears to be an ageing star in the early stages of forming a butterfly-like planetary nebula. These observations of the red giant star L2 Puppis from the ZIMPOL mode of the newly installed SPHERE instrument also reveal a close stellar companion. The dying stages of the lives of stars continue to pose many riddles for astronomers. Credit: ESO/P. Kervella

Some of the sharpest images ever made with ESO's Very Large Telescope have, for the first time, revealed what appears to be an ageing star giving birth to a butterfly-like planetary nebula. These observations of the red giant star L2 Puppis, from the ZIMPOL mode of the newly installed SPHERE instrument, also clearly showed a close stellar companion. The dying stages of stars continue to pose astronomers with many riddles, and the origin of such bipolar nebulae, with their complex and alluring hourglass figures, doubly so.

At about 200 light-years away, L2 Puppis is one of the closest [red giants](#) to Earth known to be entering its final stages of life. The new observations with the ZIMPOL mode of SPHERE were made in visible light using extreme adaptive optics, which corrects images to a much higher degree than standard adaptive optics, allowing faint objects and structures close to bright sources of light to be seen in greater detail. They are the first published results from this mode and the most detailed of such a star.

ZIMPOL can produce images that are three times sharper than those from the NASA/ESA Hubble Space Telescope, and the new observations show the dust that surrounds L2 Puppis in exquisite detail. They confirm earlier findings, made using NACO, of the dust being arranged in a disc, which from Earth is seen almost completely edge-on, but provide a much more detailed view. The polarisation information

from ZIMPOL also allowed the team to construct a three dimensional model of the dust structures.

The astronomers found the dust disc to begin about 900 million kilometres from the star - slightly farther than the distance from the Sun to Jupiter - and discovered that it flares outwards, creating a symmetrical, funnel-like shape surrounding the star. The team also observed a second source of light about 300 million kilometres - twice the distance from Earth to the Sun - from L2 Puppis. This very close companion star is likely to be another red giant of a similar mass, but younger.

The combination of a large amount of dust surrounding a slowly dying star, along with the presence of a companion star, mean that this is exactly the type of system expected to create a bipolar [planetary nebula](#). These three elements seem to be necessary, but a considerable amount of good fortune is also still required if they are to lead to the subsequent emergence of a celestial butterfly from this dusty chrysalis.

Lead author of the paper, Pierre Kervella, explains: "The origin of bipolar planetary nebulae is one of the great classic problems of modern astrophysics, especially the question of how, exactly, [stars](#) return their valuable payload of metals back into space - an important process, because it is this material that will be used to produce later generations of planetary systems."

In addition to L2 Puppis's flared disc, the team found two cones of material, which rise out perpendicularly to the disc. Importantly, within these cones, they found two long, slowly curving plumes of material. From the origin points of these plumes, the team deduces that one is likely to be the product of the interaction between the material from L2 Puppis and the companions star's wind and radiation pressure, while the other is likely to have arisen from a collision between the stellar winds

from the two stars, or be the result of an accretion disc around the companion star.

Although much is still to be understood, there are two leading theories of bipolar planetary nebulae, both relying on the existence of a binary star system. The new observations suggest that both of these processes are in action around L2 Puppis, making it appear very probable that the pair of stars will, in time, give birth to a butterfly.

Pierre Kervella concludes: "With the companion star orbiting L2 Puppis only every few years, we expect to see how the [companion star](#) shapes the red giant's disc. It will be possible to follow the evolution of the dust features around the star in real time - an extremely rare and exciting prospect."

More information: This research was presented in a [paper](#) entitled "The dust disk and companion of the nearby AGB star L2 Puppis", by P. Kervella, et al., to appear in the journal *Astronomy & Astrophysics* on 10 June 2015.

Provided by ESO

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