The circumstellar disk, envelope, and bi-polar outflow of the Massive Young Stellar Object W33A

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The Young Stellar Object (YSO) W33A is one of the best known examples of a massive star still in the process of forming. Here we present Gemini North ALTAIR/NIFS laser-guide star adaptive-optics assisted K-band integral-field spectroscopy of W33A and its inner reflection nebula. In our data we make the first detections of a rotationally-flattened outer envelope and fast bi-polar jet of a massive YSO at near-infrared wavelengths. The predominant spectral features observed are Br-gamma, H_2, and a combination of emission and absorption from CO gas. We perform a 3-D spectro-astrometric analysis of the line emission, the first study of its kind. We find that the object's Br-gamma emission reveals evidence for a fast bi-polar jet on sub-milliarcsecond scales, which is aligned with the larger-scale outflow. The hybrid CO features can be explained as a combination of hot CO emission arising in a disk close to the central star, while cold CO absorption originates in the cooler outer envelope. Kinematic analysis of these features reveals that both structures are rotating, and consistent with being aligned perpendicularly to both the ionised jet and the large-scale outflow. Assuming Keplerian rotation, we find that the circumstellar disk orbits a central mass of >10Msun, while the outer envelope encloses a mass of ~15Msun. Our results suggest a scenario of a central star accreting material from a circumstellar disk at the centre of a cool extended rotating torus, while driving a fast bi-polar wind. These results therefore provide strong supporting evidence for the hypothesis that the formation mechanism for high-mass stars is qualitatively similar to that of low-mass stars.

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