Asymmetric Planetary Nebulae III
ASP Conference Series, Vol. XXX, 2004
M. Meixner, J. Kastner, B. Balick and N. Soker eds.

The extraordinary planetary nebula N66 in the LMC

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Abstract.
Morphology of the planetary nebula LMC-N66 (ionized by a [WN] star) indicates that the nebula is a multipolar object with a very narrow waist. It shows several jets, knots and filaments in opposite directions from the central star. A couple of twisted long filaments could be interpreted as due to point-symmetric type ejection. If such is the case, the progenitor would be a binary precessing system. High resolution spectroscopy shows that most of the material is approaching or receding from the star. However the line profiles are very complex, showing several components at different velocities. Our high resolution spectroscopic data show that the different structures (knots, filaments, ...) present different radial velocities spreading from 240 to more than 400 km s^{-1}. The system velocity is 300 km s^{-1}. There are high velocity knots located to the north of the central star, moving at more than 100 km s^{-1} relative to the system velocity.

1. Introduction

The extraordinary planetary nebula LMC-N66 has been the subject of many studies since the outburst showed by its central star in 1993, when suddenly it developed huge WN features which have been fading with time. Previous discussion on the stellar and nebular parameters can be found in Peña et al. (1994, 1995, 1997). Recent analysis of the stellar data for different pre- and post-outburst epochs has been performed by Hamann et al. (2003), who suggest that extraordinary event occurred in the central star could be explained by transfer of mass in a close binary object.

We are presently analyzing the kinematics and morphology of the nebula, searching for evidence of a possible binary star as the progenitor of the N66. Previous analysis of the morphology and kinematics of the nebula can be found in Blades et al. (1992), Dopita et al. (1993), Vassiliadis (1996) and Vassiliadis et al. (1998). Together with an extraordinary multipolar appearance, N66 also presents an extraordinary energetics, showing several velocity components in a

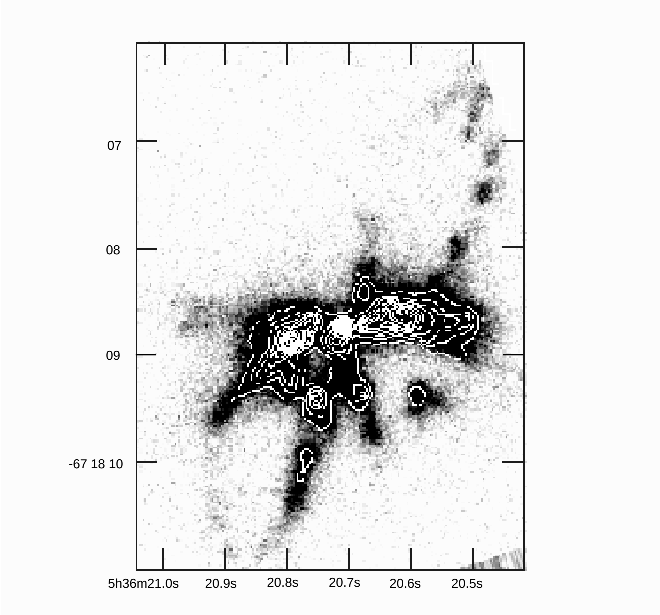

Figure 1. The FOC HST image X25H101T, obtained through the F501N filter, shows the "butterfly" morphology of LMC-N66.

range from about 240 to more than 400 km s^{-1}. Dopita et al. (1993) have found at least four components spreading in velocity over a range of 225 km s^{-1}.

2. The morphology and kinematics

We have obtained HST STIS high resolution spectroscopy of some knots and filaments near the central star and also high resolution spectra of the whole object, employing the ESO VLT telescope. Together with some HST images retrieved from the archives, these data allow us to analyze the kinematics in combination with the morphology of the ionized gas. A detail description of the spectroscopic data will be presented elsewhere.

Figure 1 corresponds to the FOC HST image X25H101T, retrieved from the archives. This image was obtained with the filter F501N which isolates the intense [O III] 5007 Å line. The extraordinary "butterfly" morphology of the nebula is evident.

Our preliminary conclusions, from the morphological and kinematical analysis, are:

1. High spatial resolution images show a complex morphology, including two bright lobes at both sides of the star and several knots and filaments located in opposite directions. The most interesting structures are a couple of long bent filaments, oriented towards opposite sides from the central star which clearly remind some bent structures found in point-symmetric type planetary nebulae. The longest (projected) extension of the filaments is about $2''$, which represents 0.5 pc at the LMC distance. These filaments seem to close forming long loops.

2. Our VLT high-resolution spectroscopic data show that the gas presents a highly bipolar kinematics, with most of the material approaching or receding from the central star. The west lobe is approaching at velocity of about 240-270 km s^{-1}, while the east lobe is mainly receding at 330 km s^{-1}. However, the line profiles are complex and the approaching and receding material present several components.

3. The knots located to the north of the central star have very large radial velocity, receding from the central star at more than 100 km s^{-1}.

4. The knots and filaments to the south of the star are moving at small (approaching) velocities, relative to the system.

5. The kinematics and the morphology are indicating that N66 is a multi-polar nebula, with jet-like ejections and twisted knotty filaments that could have been ejected by a precessing source. If this is confirmed by deeper kinematical studies, then the progenitor of N66 would be a binary system. Interestingly, the possible binariety of the central star is also supported by the analysis of the stellar evolutionary status (Hamann et al. 2003).

Acknowledgments. This work was partially supported by DGAPA/UNAM (grant IN114601), CONACYT-Mexico (grant 34594-E). M.T.R. received partial support from FONDAP/Chile (#15010003), a Guggenheim Fellowship and Fondecyt/Chile (#1010404).

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