PLANETARY NEBULAE: THEIR EVOLUTION AND ROLE IN THE UNIVERSE
IAU Symposium, Vol. 209, 2003
S. Kwok, M. Dopita, and R. Sutherland, eds.

The LMC Planetary Nebula N66 Revisited: Nebular Kinematics and Stellar Models

M. Peña(1), W.-R. Hamann(2) and M. T. Ruiz(3)

(1)*Instituto de Astronomia, UNAM, Mexico*
(2)*Lehrstuhl Astrophysik der Universität Potsdam, Germany*
(3)*Depto. de Astronomía, Universidad de Chile, Chile*

1. Introduction

LMC–N66 is an extraordinary planetary nebula whose central star underwent a violent mass loss event which has lasted for 10 years. The outburst reached its maximum in 1994. Since then the star has been slowly fading. During the stellar outburst, the nebular lines have shown no changes.

The nebula shows a complex morphology. Two very bright lobes at both sides of the central star, almost aligned in the E-W direction, constitute the main body of the nebula. Several knots and filaments are conspicuous over the surface lying preferentially on the S-E and N-W directions. A couple of faint extended loops are also detected in the S-E and N-W directions at both sides of the star. The extension of these loops are larger than 0.5 pc at the LMC distance. A no emitting-zone in the S-W quadrant, seems to be part of a dusty toroid around the central star, although the central star is not obscured by such a dark material (see Blades et al. 1992 for a description of N66 morphology).

We obtained *HST*–STIS long-slit ($52'' \times 0.2''$) observations at high and low resolution during Cycles 7 and 8. MAMA and CCD detectors were used to cover the widest possible spectral range. The position angle of the slit in Cycle 7 was P.A.= $-20.7329°$ and in Cycle 8 it was P.A.= $+5.6086°$. Thus, we have detected the stellar emission and also the emission lines from several knots and filaments located in the S-E and N-W directions, at both sides of the central star. The kinematics of some knots, as well as the stellar emission, were analyzed and some of the results are presented in this work.

2. High resolution spectra: kinematics and morphology

From our high resolution spectra of the nebular features, we have found that knots and filaments located South-East from the central star present velocities in the range from -38 to -59 km s^{-1}, while features in the opposite side are redshifted with velocities of about $+60$ km s^{-1}, relative to the systemic velocity (which has been taken as the average between blue and red velocities and resulted to be $+368$ km s^{-1}).

Therefore our high resolution spectra show the following kinematical behavior:

• The nebular features in the S-E zone are moving towards us with v~ -60 km s^{-1} while the gas in the N-W side is going in the opposite direction with v$\sim$

https://doi.org/10.1017/S0074180900209777 Published online by Cambridge University Press

60 km s^{-1}. We postulate that the observed knots and filaments were produced by bipolar ejections from the central star, which were probably focussed by a dense ring around it. The dense material is located in such a way that the star is not obscured by the dust (almost pole-on system?).

• The nebular loops have a physical extension larger than 0.5 pc. Our expansion velocities imply a kinematical age larger than about 5000 years for the edge of the loops while the knots nearest to the central star should have been ejected only some 500 years ago.

LMC-N66 is a PN where material ejections have been performed along thousands of years, in probably episodic events.

3. The central star

Stellar continuum and lines, for different epochs, have been analyzed by means of improved models for expanding atmospheres (see Hamann, these proceedings). Important stellar parameters provided by the models are presented in the Table.

Stellar parameters

Epoch	1983	1995	1999
T_{eff} (kK)	112	89	112
log L	4.58	4.98	4.55
R_*	0.52	1.30	0.50
log $\dot{M}$	-5.46	-4.93	-5.56

Thus, models show that at outburst the star increased its bolometric luminosity by a factor of 2.5, by increasing its radius by a large amount: from 0.5 to 1.3 $R_\odot$. Consequently, T_{eff} diminished. Simultaneously the mass loss rate increases by a factor of 3.4. At ten years from the beginning of the outburst the star is returning to its initial conditions.

Our preliminary models indicate that N66 position in the HR diagram changed during the event. Therefore, and contrary to our previous conclusions (Peña et al. 1997), essential stellar characteristics (L_*, R_*) might have changed significantly producing the mass-loss event. The origin of the phenomenon ongoing in N66 remains unknown. An atmosphere instability, as claimed by Peña et al. (1997) cannot be discarded but all the event should be rediscussed under the light of the new results.

References

Blades, J. C., et al., 1992, ApJ, 398, L41

Hamann, W.-R., IAU Symp. 209, these proceedings

Peña, M., Hamann, W.-R., Koesterke, L., Maza, J., Méndez, R., Peimbert, M., Ruiz, M.T., & Torres-Peimbert, S., 1997, ApJ, 491, 233

https://doi.org/10.1017/S0074180900209777 Published online by Cambridge University Press