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Evidence of Jets in the Bipolar Planetary Nebulae M 1-91 and M 1-92

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Abstract. For M1-91 we find that the ratio of the 6717/6731 [S II] narrow band images shows two symmetrical very collimated high density regions, or jets, along the major axis.

We infer many properties of M 1-92 from the similarity of the spectral features with the symbiotic star MWC 560. We show that M 1-92 could also have a jet along the major axis and that from the NW knot we receive scattered light from the central region that has traveled along the line of symmetry.

1. Observations

They were carried out at the Observatorio Astronómico Nacional, at San Pedro Mártir with a 1024×1024 CCD Tektronix. We used the 1.5-m telescope for direct image (0.24"/pix), and the 2.1-m telescope for echelle spectroscopy at a spectral resolution from 0.13 Å/pix at 3700 Å to 0.24 Å/pix at 6560 Å.

2. M 1-91

It is an extremely elongated object of 45" × 4.6" (Machado et al. 1996) with bright point-symmetric condensations. The lobes are polarized (∼20%) at optical wavelengths (Trammell 1994). From J and K images Dimeo & Trammell (1997) consider that the knots correspond to local emission and that they are not significantly affected by scattered light.

From the direct image isocontours it can be appreciated that the maxima along the lobes follow a symmetric helical curve up to 15" from the nucleus, suggesting precession. The bright condensations do not show peculiar velocities relative to the rest of the nebula, possibly due to illumination effects.

We find from the 6717/6731 [S II] image ratio, a narrow band of high density material ($> 10^6$ cm^{-3}) superimposed over the mean nebular density of $\sim 5\times10^3$ cm^{-3} of dimensions of 1.5" × 25". We propose that the observed high density gas is part of two opposite beams of collimated non-radiative particles, or jets, similar to that proposed by Doyle et al. (2000) for M 2-9. The helicoidal shape of the maxima is consistent with two jets precessing at 7° around the bipolar axis. For an inclination angle of the bipolar axis relative to the plane of the sky of 15° (Carsenty & Solf 1982), a value of 20 km s^{-1} for the velocity of the lobes in the nebula and a distance of 1 kpc, we derive a precession period of $\sim$ 500 years.

3. Is M 1-92 similar to the symbiotic star MWC 560?

Optical, infrared and millimeter images of this proto-planetary nebula show two extended symmetrical lobes. Trammell et al. (1993) observed continuum and permitted emission lines to be highly polarized, not so the forbidden lines. They concluded, that the continuum and permitted lines are formed in the central star and that dust in the lobes is scatters light originating from the central region.

The spectrum of the M 1-92 NW knot shows wide permitted lines in emission with a detached blueward absorption; while the spectrum from the central regions does not show these absorption features. Altogether the M 1-92 NW knot spectrum is similar to that of MWC 560, with absorption at 700 km s^{-1} in M 1-92 and at 2300 km s^{-1} in MWC 560. There are no molecular absorption lines in the continuum spectrum of M 1-92, in contrast to MWC 560.

MWC 560 is a symbiotic star composed of a red giant and a white dwarf. In our spectrum the system shows velocities of about 2300 km s^{-1} and the detached absorption features are clearly seen in H I, He I 5876, Na I D and Fe II lines. Schmid et al. (2001) interpreted the permitted emission lines as originating in an accretion disk seen face on. Shore et al. (1994) explained the absorption profile by a collimated outflow, observed along the axis.

M1-92 could be a symbiotic star similar to MWC 560 with an F2III companion (e. g., Feibelman & Bruhweiler 1990). We suggest that the detached absorption from the bright NW knot originates in the central regions, and has traveled through the major axis, and has been scattered in our direction. This is consistent with the result from the HST image of Bujarrabal et al. (1998) that the optical line emission comes mainly from two chains of shocked knots placed along the symmetry axis of the nebula.

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