

The Planetary Nebula Kn 61

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ABSTRACT

Kn61 is a planetary nebula that has been recently discovered. In this work we investigate its spectral properties and its spatio-kinematical structure through low-medium and high-resolution spectroscopic observations. We have also obtained narrowband imagery in [O III] and H α for the nebula. The new data for Kn61 reveal characteristics of an hydrogen deficient planetary nebulae since we only detected [O III], HeII and very weak K α and H β emission in the nebular optical spectra. Photometric observations do not show brightness variations of the central star, beyond detection limit.

Introduction

Kn 61 is a filamentary spherical nebula, classified as a probable planetary nebula (PN) due its structure is similar to PN A 43 (Douchin et al. 2011). Kn 61 has a central star known as SDSSJ192138.93+381857.2 which present a visual magnitude of 18.2 (data from Digital Sky Survey). The distance has been calculated roughly 4 kpc (<http://www.gemini.edu/node/>). A Gemini Observatory image of [O III] and H of the nebula, shows emission only in the blue plate.

Observation: Imaging

The monochromatic images of Kn61 were performed in 2012, when we used the Mexman filter wheel on the 84 cm telescope at the Observatorio Astronómico Nacional de San Pedro Mártir (OAN-SPM). We used ESOPO CCD detector with 2048x2048 square pixels. Kn61 was observed in the light of [O III]5007A, Ha6563A, [S II]6731A and [N II]6584A with bandwidths of 52, 11, 54 and 10 Å respectively.

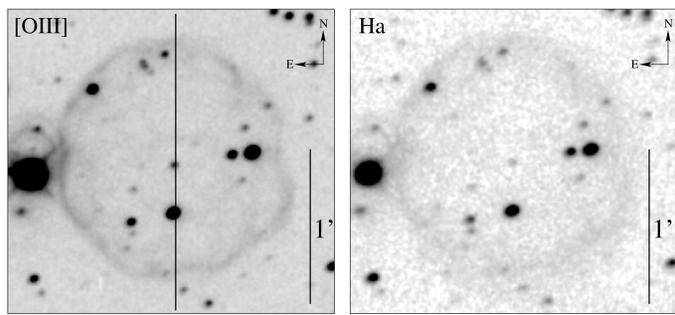


Figure 1. Image of Kn61 obtained at SPM in the light of [O III] 5007 Å (left) and H α (right). The [O III] image show a highly filamentary bubble (Douchin et al. 2011), where the brightness maximum is in the borders. The H α image is extremely faint. The outline of the bubble in the [O III] and H α images cover the same area.

Photometry

Kn61 was observed using the 84 cm and 1.5m telescope at OAN-SPM. The 84 cm telescope was equipped with the ESOPO CCD for direct imaging, and a filter wheel with Johnson filters. The 1.5m telescope was equipped with the RATIR instrument using the r and i filter simultaneously (see table 1.)

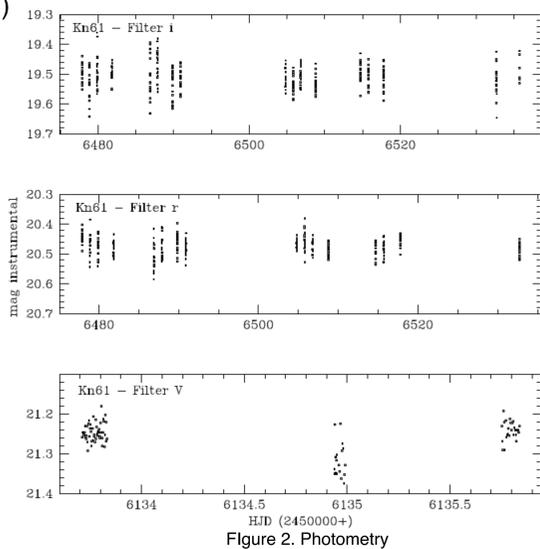


Figure 2. Photometry

Long-slit observation

The data were taken at the OAN-SPM using the MES-SPM on the 2.1m telescope in a f/7.5 configuration and are available in the "SPM catalogue of Galactic Planetary Nebulae" (López et al 2012). We used two different filters: Ha+[N II] and [O III]5007 with bandwidths of 90 Å and 50 Å respectively. Figure 1 shows the location of the slit in the light of [O III]5007.

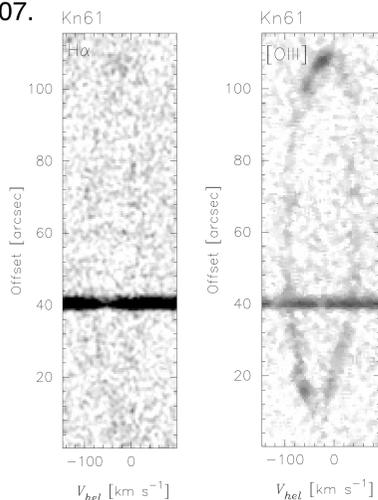


Figure 3. Bi-dimensional (P-V) array, without subtracting the continuum from central star. the declination scale is arbitrary and the stellar continuum from a field star has not been subtracted from the spectral of nebula. The H α emission line is extremely faint. We did not detect [N II] line emission in the region covered by the slit

Low resolution spectroscopy observations

Low-intermediate resolution spectroscopy was performed with 2.1 m telescope at OAN-SPM. We used the B&Ch spectrograph with grating of 600l/mm and 1200l/mm with a FWHM of 4.1 Å and 2.05Å respectively. (see table2).

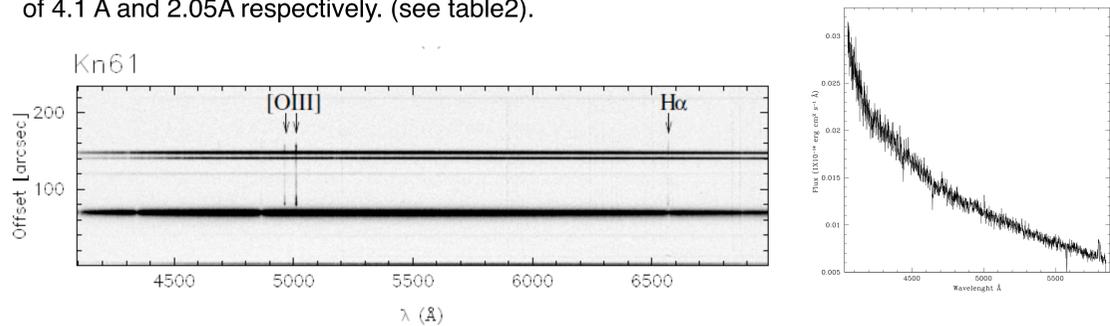


Figure 4. Right panel: spectra one dimension from the central star. left panel: two dimension spectrum of nebula

Medium-resolution spectroscopic data

of Kn61 were recently obtained at the Special Astrophysical Observatory 6-m telescope in 2013, september 12, using the SCORPIO spectrograph(Afanasiev & Moiseev 2005) installed at the prime focus of the SAO 6m telescope of the Russian Academy of Sciences in the long-slit unit mode. Three spectra were taken in the spectral range between 3900 Å and 5700 Å

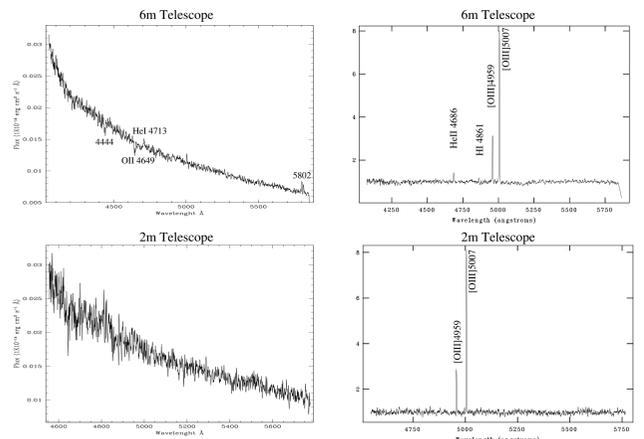


Figure 5. Top row Left: stellar spectra of Kn61 at SAO. Right: Nebular spectrum of Kn61 form SAO. Bottom row Left: Stellar of Kn61 at OAN-SPM. Left: Nebular spectrum of Kn61 at OAN-SPM

Results:

P – V array in the light of [O III], we found that the velocity splitting at the center amounts to 135.32 km/s with the blueshift component at -93.02 km/s and the redshift component at +42.30 km/s. This yields an expansion velocity of 57.12 km/s.

The systemic heliocentric velocity, as measured from the midpoint between the line splitting is -25.36 km/s. We calculated a crude estimate of the kinetic age for the nebula, considering that the angular diameter of the nebula is 104", taking a distance of 4 kpc, its linear radius in parsec is 0.96 pc. This implies a kinematic age for the bubble of 16000 yrs. Noteworthy is the small tilt in the line profile; produced by localized velocities from filaments at the edge of the bubble since the overall geometry looks spherical. The [O III] P-V diagram reveals that Kn61 is a closed, empty shell with a thin border. Figure 4 (right panel) shows a low resolution spectrum of the central star of Kn 61 taken from 2.1 m from OAN-SPM. With these data, we could not identify any absorption line in the photospheric spectrum given the poor signal to noise ratio in the data. The central star at 18 mag is the limit of the detection for the telescope used. The medium-resolution spectra from SAO (Figure 5) for the star reveals the the He and OII absorption lines, while the nebular spectrum shows, in addition to the OIII lines, very faint HeII and H β line emission. Planetary nebulae typically present HI and HeI recombination lines, and including HeII lines, the collisionally excited lines of [OIII], [NeIII] and [Ne V] are often strong. However, the medium-resolution spectroscopy observations of Kn61 do not show such lines except for H I and [O III]. We see that in the photometry for i, r and V filters there is variability per night of 0.2 mag for Kn 61, but there is no clear evidence of an orbital modulation.

Full details of this work will be published soon.

table1. Photometric observations

Date	Filter	time (s)	No. Frames	Telescope (m)
Kn 61				
24,25,26/07/2012	v	300	19/19	0.84
4,5,6,8,13,14,16,17,31/07/2013	R/I	90/90	19/19	1.5
1,2,4,10,11,13,28/08/2013	R/I	90/90	20/20	1.5
31/08/2013	I	90	20	1.5

table2. Low-spectroscopy observation

Date	No. Frames	spectral range (Å)
Kn61		
11/08/2013	1	400 - 7000
12/09/2012	2	4560- 5750
17/07/2012	3	4000- 7000
16/07/2012	1	4560- 5750
09/06/2012	6	4560- 5750