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SMC SMP 24: A NEWLY RADIO-DETECTED PLANETARY NEBULA IN THE SMALL MAGELLANIC CLOUD

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SUMMARY: In this paper we report new radio-continuum detection of an extragalactic PN: SMC SMP 24. We show the radio-continuum image of this PN and present the measured radio data. The newly reduced radio observations are consistent with the multi-wavelength data and derived parameters found in the literature. SMC SMP 24 appear to be a young and compact PN, optically thick at frequencies below 2 GHz.

Key words. ISM: planetary nebulae – Magellanic Clouds – Radio Continuum: – ISM: individual objects – SMC SMP 24

1. INTRODUCTION

The importance of the radio-continuum properties of planetary nebulae (PNe) has been recently reinstated with the report of the radio-continuum observations of PNe in the Magellanic Clouds (Filipović et al., 2009). The comprehensive multifrequency study, based on Australia Telescope Compact Array+Parkes mosaic surveys of Magellanic Clouds (MCs) (Hughes et al. 2006, 2007; Payne et al. 2004, 2009; Filipović et al. 1995, 1997, 2002, 2005, 2008), helped to reveal the true nature of more than 50 PN candidates in MCs as compact H II regions. Also, based on our radio data, Reid & Parker (2010) were able to re-classify three ultra-bright PNe (previously classified as 'true' PNe) as contaminants due to their strong radio fluxes. Our MCs radio PNe detections represent only ∼3 per cent of the optical PNe population of the MCs. Most likely, we are selecting only the strongest radio-continuum emitters, possibly at a variety of different stages of their evolution (Vukotić et al. 2009).

Prior to this study, a radio detection of only three extragalactic PNe have been reported in the literature (Zijlstra et al., 1994; Dudziak et al., 2000). Based on the radio-continuum properties of radio-bright Galactic PNe the expected radio flux densities at the distance of the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC) are up to ∼2.5 and ∼2.0 mJy at 1.4 GHz, respectively. While the LMC sample conform with the radio luminosity limit predicted from Galactic PNe, the SMC PNe sample appear to be unusually strong radio emitters.

The known and well refined distances to the LMC/SMC provide a great opportunity for the accurate evaluation of important physical properties for PNe such as ionised massed and electron densities. Also, a statistically significant sample of radio detected extragalactic PNe will allow the construction and examination of the bright end of the radio PN luminosity function (PNLF) and comparison with established theoretical and empirical MCs PNLF's obtained at other wavelengths (Jacoby et al., 1990; Mendez et al., 1993; Stanghellini, 1995; Jacoby & De Marco, 2002; Ciardullo et al., 2002).

Therefore, we initiated a deep, 6 cm radio-continuum survey which will attempt to detect and accurately measure the radio-continuum flux densities of 50+ MCs PNe. As a first step in this project we thoroughly examined the archived Australia Telescope Compact Array (ATCA) data (the Australia Telescope Online Archive[1]) in order to find if any of the objects have been already observed and to estimate upper flux limits for the prepared sample. In this paper we report the radio detection of SMC SMP 24 (hereafter SMP 24), found in the ATCA's archival deep observation of the SMC supernova remnant SNR 0101-7226 conducted in 1993/1994 by Ye et al. (1995).

2. Multiwavelength data

SMP 24 (LHA 115 − N S70; Henize, 1956) is a SMC PN located approximately 2 arcmin north of the N S66 giant star-forming complex. From its appearance in Hα and [O III] spectral lines, Stanghellini et al. (2003) designated this PN as an elliptical with a possible faint halo. The authors reported a flux calibrated intensity in the Hβ line, optical extinction ($c_{H\beta}$), and relative intensities of several bright spectral lines. Also, the photometric radii of the nebula and the nebular dimensions, measured from the 10% brightness contour have been reported. They determined electron density of $\log n_e \approx 3.1$ from [S II]$\lambda\lambda$6716,6731 lines and calculated ionised mass of the nebula ($M_i \approx 0.86$ $M_\odot$). It is important to note that the reported ionised mass, calculated using the eq. 6 from Boffi & Stanghellini (1994), is, by a factor of 2.8 and 4, larger than the average mass of the rest of PNe from the SMC and LMC sample reported in this paper, respectively. From the [O II] electron density diagnostic (I(λ3726.0)/I(λ3728.8), Stanghellini et al. (2009) and Shaw et al. (2010) reported a significantly higher electron density for this PN of $\log n_e \approx 3.4$. Assuming that the rest of the parameters used by Stanghellini et al. (2003) stay the same, the new electron density estimate will half the ionised mass to $M_i \approx 0.4$. The newly obtained mass is in a much better agreement with the rest of the SMC PNe sample. We tabulated the reported data, relevant to this study, in Table 1.

SMP 24 is observed as a part of spectroscopic observations of 25 MCs PNe conducted with the *Spitzer Space Telescope* Infrared Spectrograph (Bernard-Salas et al. 2009). The presence of hydrogenated amorphous carbon molecules (HACs) in this PN, is interpreted by the authors as an evidence of the early evolutionary stage. The SMP 24 central star is characterised by a very low ionisation potential, also noticed by Stanghellini et al. (2009) (EC 1-2). Also, this PN is detected in the Spitzer Survey of the Small Magellanic Cloud (S^3MC: Bolatto et al. 2007), which imaged the star-forming body of the SMC in all seven MIPS and IRAC wave bands. Measured flux densities from the B band to the 70 μm band (where the PN is not detected) are tabulated in Table 2.

3. 20 cm detection of SMP 24

SMP 24 was observed by T. Ye, S. Amy, L. Ball and J. Dickel with the ATCA as a part of project C281 over two 12 hour sessions on 25th August 1993 and 10th February 1994. Two complementary array configurations at 20/13 cm (ν=1377/2377 MHz) were used – 1.5B and 6B. However, SMP 24 is positioned some $\sim$18$'$ from the pointing centre and therefore appeared outside of the primary beam of the 13 cm observations. The source 1934-638 was used for primary calibration and source 0252-712 as the secondary calibrator. More information about observing procedure and other sources observed during these sessions can be found in Ye et al. (1995).

The MIRIAD (Sault and Killeen 2010) and KARMA (Gooch 2006) software packages were used for reduction and analysis. The initial, high-resolution image was produced from the full data-set and using MIRIAD multi-frequency synthesis (Sault and Wieringa 1994) and natural weighting. The obtained 20 cm image has a resolution of 7.0$''\times$6.6$''$ at PA=42.6° and an estimated r.m.s. noise of 0.05 mJy beam^{-1} which is significantly better than Ye et al. (1995) of 0.1 mJy beam^{-1}. We attribute this difference to slightly different cleaning technique and careful flagging of very noisy observational data. The new high-resolution and high-sensitivity analysis of these observations will be presented in the future papers.

However, due to the effect of the decreasing phase stability with increasing baseline length, which could affect the position and the flux density estimate of faint, point like sources, we created additional "low-resolution" total intensity image by excluding long baselines (i.e. without correlations with antenna 6). The excerpts from this "low-resolution" map, which is used in this study, are presented in Fig. 1. The map has a resolution of 15.3$''\times$14.4$''$ at PA=39.8° and an estimated local r.m.s. noise of 0.1 mJy beam^{-1} measured from the $\sim$8$'\times$8$'$ box centred on the SMP 24.

[1]http://atoa.atnf.csiro.au/

In order to confirm the positional correlation between the newly found radio source and SMP 24 we created a colour composite (RGB) image of the SMP 24 region using data from the Magellanic Cloud Emission Line Survey (MCELS: Smith & The MCELS Team, 1999). Figure 2 (left) represents the region of the SMC centred on SMP 24. The PN can be seen in the centre of the field as a distinctive blue point source. In Figure 2 (right) we show a radio-continuum contour map of SMP 24 superposed on the MCELS colour composite image. From Figure 2 can be seen that the peak flux in the radio appear to be well correlated with the peak flux in the optical line emission.

The position and the peak flux density of the SMP 24 was determined by fitting a two-dimensional Gaussian to the restored and beam-corrected total intensity map. We used MIRIAD's task IMFIT with a clip level of 5 σ (where σ is the measured local r.m.s. noise). All pixels below the clipping level were excluded from the fitting process. The error in the measured peak flux density is estimated as a quadrature sum from the locale noise level (0.1 mJy beam^{-1}) and the uncertainty in the gain calibration (10%). However, due to the non-linear systematic errors which can arise from a large distance from the phase centre and a low signal to noise ratio (e.g. CLEAN bias), we applied additional 30% of uncertainty in the final flux density estimate. The results and the parameters used in the fitting procedure are presented in Table 2.

4. Discussion

The presented multi-wavelength data is in good agreement with suggestion that SMP 24 is a very young PN (Bernard-Salas et al., 2009). The 20 cm peak flux density observed in this PN corresponds to a low limit for the radio surface brightness temperature of $\sim 4.3 \times 10^3$ K (assuming upper limit for the angular diameter of $\theta \approx 0.38$). This implies optically thick or at least partially optically thick radio-continuum emission at 20 cm. The same implication can also arise from a comparison between the measured radio flux density and the flux derived from the Hβ emission line. Due to the same dependence on the nebular density it is expected that the centimeter radio-continuum emission and Balmer lines emission will be well correlated (see Pottasch, 1984 eq. IV-26). From parameters tabulated in Tab. 1 (F(Hβ), c(Hβ), T_e and $n(He^+)/n(H^+)$) we estimated flux at 1.4 GHz of 1.1 mJy. Although within uncertainty range, this 40% deviation from the measured 1.4 GHz radio-continuum flux indicate that the self-absorption by the nebula is important in this frequency band and implies an existence of significant density stratification (where the reported $\log n_e \approx 3.4$ cm^{-3} is probably only the average).

The empirical and modelled spectral energy distributions (SED) of SMP 24 are presented in Figure 3. Since only one observation is available in the radio-continuum band we roughly estimated the position of the turnover (critical) frequency using the obtained brightness temperature at 20 cm. From $T_b = T_e(1 - e^{-\tau_\nu})$ we found an average optical depth at 20 cm of $\tau_{20cm} = 0.47$. The critical frequency (ν_c) can now be found from: $\tau_\nu = (\nu/\nu_c)^{-2.1}$ (Pottasch, 1984). From these two point we constructed the SED for SMP 24 using the simple approximation of the uniformly ionised region with constant density and constant electron temperature (see eq. 4 in Sharova, 2002).

Assuming that SMP 24 is a young planetary nebula, we expect that its central star will be still closely surrounded by the ejected dusty envelope. In order to estimate the dust temperature (T_d) we fitted a blackbody spectrum to the far IR (FIR) data. It is important to note that the R_{phot} measurement from Stanghellini et al. (2003) is used as an estimate for angular diameter of the emitting dust. Also, no attempt was made to estimate the optical depth in IR bands. The best fit is obtained with $T_d \approx 270$ K (Fig. 3: dashed line). However, in order to better reproduce the observed SED down to 1 μm we fitted additional hot dust component in the mid and near IR bands (MIR and NIR, respectively) with estimated $T_{hd} \approx 1000$ K (dot-dashed line) and with the same approximations used for the FIR band. The summed SED of the radio-continuum, dust and the hot dust was plotted in Fig 3 with solid line. The MIR to radio ratio for this object is found to be $\sim$12 which is in accord with a range of values expected for PNe (Cohen & Green, 2001; Cohen et al., 2007).

For comparison we overplotted the observed radio-continuum to IR SED of young Galactic PN IC 418 scaled to the distance of SMC. Observational data is from Meixner et al. (1996); Guzmán et al. (2009); Pazderska et al. (2009) and Vollmer et al. (2010) and with adopted distance to this PN of 1.3 kpc (Guzmán et al., 2009). This object is already used by Bernard-Salas et al., (2009) for a comparison with SMC PNe SiC feature (broad feature from 9 to 13 μm seen regularly in carbon stars but very rarely in Galactic PNe). IC 418 is a bright and young C-rich Galactic PN with well defined ring structure with angular diameter of $\sim$12 arcsec ($\sim$0.25 arcsec scaled to the SMC distance). It is surrounded with a low-level ionised halo and embedded in a large molecular envelope (Taylor et al., 1989; Hyung et al., 1994). As can be seen from Fig. 3 IC 418 shows a clear similarity in SED with SMP 24.

5. Summary

In this paper we presented detection of the radio-continuum emission from the SMC PN: SMP 24. This object is a radio luminous PN with estimated flux density at 1.4 GHz of 0.7±0.4 mJy (∼2.7 Jy scaled to the distance of 1 kpc). Because of the relatively high brightness temperature at 1.4 GHz and the significant difference between the measured radio-continuum flux and predicted from Hβ we conclude that the ionised shell of this PN is very likely optically thick (or partially optically thick) at frequencies below 2 GHz. However, it is important to note that in order to properly examine radio-continuum properties of this PN, the additional, multi-frequency radio-continuum data is needed. This PN is scheduled to be observed in our ATCA-based follow-up observations of MC's PNe.

We discussed the evolutionary stage and spectral energy distribution of this SMC PN in the light of the available multi-wavelength data and from the evident similarities with a young and well studied Galactic PN IC 418. SMP 24 appear to be a young PN with a dynamic age of <1000 yr. The ionised gas and the hot dust are very likely still located in the same region, close to the central star. We believe that our future, high resolution and high sensitivity radio-continuum observations of SMP 24 will help to reveal some of its intrinsic physical properties (e.g. emission measure, physical size and mass of the ionised shell).

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REFERENCES

Bernard-Salas, J., Peeters, E., Sloan, G. C., Gutenkunst, S., Matsuura, M., Tielens, A. G. G. M., Zijlstra, A. A. and Houck, J. R.: 2009, *Astrophys. J.*, **699**, 1541.

Boffi, F. R. and Stanghellini, L.: 1994, *Astron. Astrophys.*, **284**, 248.

Bolatto, A. D., Simon, J. D., Stanimirović, S., van Loon, J. T., Shah, R. Y., Venn, K., Leroy, A. K., Sandstrom, K., Jackson, J. M., Israel, F. P., Li, A., Staveley-Smith, L., Bot, C., Boulanger, F. and Rubio, M.: 2007, *Astrophys. J.*, **655**, 212.

Ciardullo, R., Feldmeier, J. J., Jacoby, G. H., Kuzio de Naray, R., Laychak, M. B. and Durrell, P. R.: 2002, *Astrophys. J.*, **577**, 311.

Cohen, M. and Green, A. J.: 2001, *Mon. Not. R. Astron. Soc.*, **325**, 531.

Cohen, M., Parker, Q. A., Green, A. J., Murphy, T., Miszalski, B., Frew, D. J., Meade, M. R., Babler, B., Indebetouw, R., Whitney, B. A., Watson, C., Churchwell, E. B. and Watson, D. F.: 2007, *Astrophys. J.*, **669**, 343.

Dudziak, G., Péquignot, D., Zijlstra, A. A. and Walsh, J. R.: 2000, *Astron. Astrophys.*, **363**, 717.

Filipović, M. D., Haynes, R. F., White, G. L., Jones, P. A., Klein, U., Wielebinski R.: 1995, *Astron. Astrophys. Journ. Suppl. Series*, **111**, 311.

Filipović, M. D., Jones, P. A., White, G. L.,Haynes, R. F., Klein, U., Wielebinski, R.: 1997, *Astron. Astrophys. Journ. Suppl. Series*, **121**, 321.

Filipović, M. D., Bohlsen, T., Reid, W., Staveley-Smith, L., Jones, P. A., Nohejl, K., Goldstein, G.: 2002, *Mon. Not. R. Astron. Soc.*, **335**, 1085.

Filipović, M. D., Payne, J. L., Reid, W., Danforth, C. W., Staveley-Smith, L., Jones, P. A., White, G. L.: 2005, *Mon. Not. R. Astron. Soc.*, **364**, 217.

Filipović M. D., et al.: 2008, in van Loon J. T., Oliveira J.M., eds, IAU Symp. **256**, The Magellanic System: Stars, Gas, and Galaxies. Cambridge Univ. Press, Cambridge, p. PDF8.

Filipović, M. D., Cohen, M., Reid, W. A., Payne, J. L., Parker, Q. A., Crawford, E. J., Bojičić, I. S., de Horta, A. Y., Hughes, A., Dickel, J. and Stootman, F.: 2009, *Mon. Not. R. Astron. Soc.*, **399**, 1098.

Gooch, R., 1996, in G. H. Jacoby & J. Barnes ed., Astronomical Data Analysis Software and Systems, **101** of *Astronomical Society of the Pacific Conference Series*, p. 80.

Guzmán, L., Loinard, L., Goḿez, Y. and Morisset, C.: 2009, *Astron. J.*, **138**, 46.

Henize, K. G.: 1956, *Astrophys. J., Suppl. Ser.*, **2**, 315.

Hyung, S., Aller, L. H. and Feibelman, W. A.: 1994, *Publ. Astron. Soc. Pac.*, **106**, 745.

Hughes, A., Staveley-Smith, L., Kim, S., Wolleben, M., Filipović M.: 2007, *Mon. Not. R. Astron. Soc.*, **382**, 543.

Hughes, A., Wong, T., Ekers, R., Staveley-Smith, L., Filipović, M., Maddison, S., Fukui, Y., Mizuno, N.: 2006, *Mon. Not. R. Astron. Soc.*, **370**, 363.

Idiart, T. P., Maciel, W. J. and Costa, R. D. D.: 2007, *Astron. Astrophys.*, **472**, 101.

Jacoby, G. H., Ciardullo, R. and Walker, A. R.: 1990, *Astrophys. J.*, **365**, 471.

Jacoby, G. H. and De Marco, O.: 2002, *Astron. J.*, **123**, 269.

Meixner, M., Skinner, C. J., Keto, E., Zijlstra, A., Hoare, M. G., Arens, J. F. and Jernigan, J. G.: 1996, *Astron. Astrophys.*, **313**, 234.

Mendez, R. H., Kudritzki, R. P., Ciardullo, R. and Jacoby, G. H.: 1993, *Astron. Astrophys.*, **275**, 534.

Oskinova, L. and Brown, J. C.: 2003, in S. Kwok, M. Dopita, & R. Sutherland ed., Planetary Nebulae: Their Evolution and Role in the Universe **209** of IAU Symposium, p. 425.

Payne, J. L., Filipović, M. D., Reid, W., Jones, P. A., Staveley-Smith, L., White, G. L.: 2004, *Mon. Not. R. Astron. Soc.*, **355**, 44.

Payne, J. L., Tauber, L. A., Filipović, M. D., Crawford, E. J., de Horta, A.: 2009, *Serb. Astron. J.*, **178**, 65

Pazderska, B. M., Gawroński, M. P., Feiler, R., Birkinshaw, M., Browne, I. W. A., Davis, R., Kus, A. J., Lancaster, K., Lowe, S. R., Pazderski, E., Peel, M. and Wilkinson, P. N.: 2009, *Astron. Astrophys.*, **498**, 463.

Pottasch, S. R.: 1984, in: Planetary nebulae - A study of late stages of stellar evolution. **.**107 of Astrophysics and Space Science Library, D. Reidel.

Reid, W. A. and Parker, Q. A.: 2010, *Mon. Not. R. Astron. Soc.*, **405**, 1349.

Sharova, O. I.: 2002, *Astronomical and Astrophysical Transactions*, **21**, 271.

Shaw, R. A., Lee, T., Stanghellini, L., Davies, J. E., García-Hernández, D. A., García-Lario, P., Perea-Calderón, J. V., Villaver, E., Manchado, A., Palen, S. and Balick B.: 2010, *Astrophys. J.*, **717**, 5622.

Smith, R. C., Team, T. M.: 1999, in Y.-H. Chu, N. Suntzeff, J. Hesser, & D. Bohlender ed., New Views of the Magellanic Clouds **190** of IAU Symposium, p. 28.

Sault, R. J., Killeen, N.: 2010, Miriad Users Guide, ATNF, Sydney.

Sault, R. J., Wieringa, M. H.: 1994, *Astron. Astrophys. Suppl. Series*, **108**, 585.

Stanghellini, L.: 1995, *Astrophys. J.*, **452**, 515.

Stanghellini, L., Lee, T.-H., Shaw, R. A., Balick, B. and Villaver, E.: 2009, *Astrophys. J.*, **702**, 733.

Stanghellini, L., Shaw, R. A., Balick, B., Mutchler, M., Blades, J. C. and Villaver, E.: 2003, *Astrophys. J.*, **596**, 997.

Taylor, A. R., Gussie, G. T. and Goss, W. M.: 1989, *Astrophys. J.*, **340**, 932.

Vollmer, B., Gassmann, B., Derrière, S., Boch, T., Louys, M., Bonnarel, F., Dubois, P., Genova, F., Ochsenbein, F.: 2010, *Astron. Astrophys.*, **511**, A53.

Vukotić, B., Urošević, D., Filipović, M. D., Payne, J. L.: 2009, *Astron. Astrophys.*, **503**, 855.

Ye, T. S., Amy, S. W., Wang, Q. D., Ball, L. and Dickel, J.: 1995, *Mon. Not. R. Astron. Soc.*, **275**, 1218.

Zijlstra, A. A., van Hoof, P. A. M., Chapman, J. M. and Loup, C.: 1994, *Astron. Astrophys.*, **290**, 228.

Table 1. SMP 24: Multi-wavelength data and parameters compiled from the literature.

Parameter			Reference
RA(2000)	00 59 16.6		1
DEC(2000)	-72 02 00.8		1
$\log \mathrm{F}(\mathrm{H}\beta : \lambda 4861)$	-12.66	$(\frac{ergs}{cm^2 s})$	2
$\mathrm{c}(\mathrm{H}\beta)$	0.047		2
R_{phot}	0.20	(arcsec)	2
θ	0.38	(arcsec)	2
T_e	11620^{+910}_{-740}K	(K)	3
$\log n_e$	3.4 ($3.1^{\dagger}$)	(cm^{-3})	3(2)
M_{ion}	0.4 ($0.86^{\dagger}$)	($\mathrm{M}_{\odot}$)	4(2)
$n(\mathrm{He}^{+})/n(\mathrm{H}^{+})$	0.097±0.011		5

References: 1) Jacoby & De Marco (2002), 2) Stanghellini et al. (2003), 3) Shaw et al. (2010), 4) this paper, 5) Idiart et al. (2007)

Table 2. SMP 24: IR data compiled from the literature.

Band	*B*	*V*	*I*	*J*	*H*	*K*	3.6 μm	4.5 μm	5.8 μm	8.0 μm	24 μm	70 μm
F_{λ}(mJy)	0.878	1.622	0.395	0.473	0.534	0.902	1.870	2.252	3.813	9.292	28.028	<(10×)5

Table 3. SMP 24: ATCA radio-continuum data.

Parameter		
Frequency	1337	MHz
Synth. Beam	15×14	(arcsec)
local r.m.s. noise (σ)	0.1	(mJy beam^{-1})
Peak Flux	0.73±0.13	(mJy beam^{-1})
Flux Density	0.7±0.4	(mJy)
RA(2000)	00 59 16.3	
DEC(2000)	-72 01 59.9	

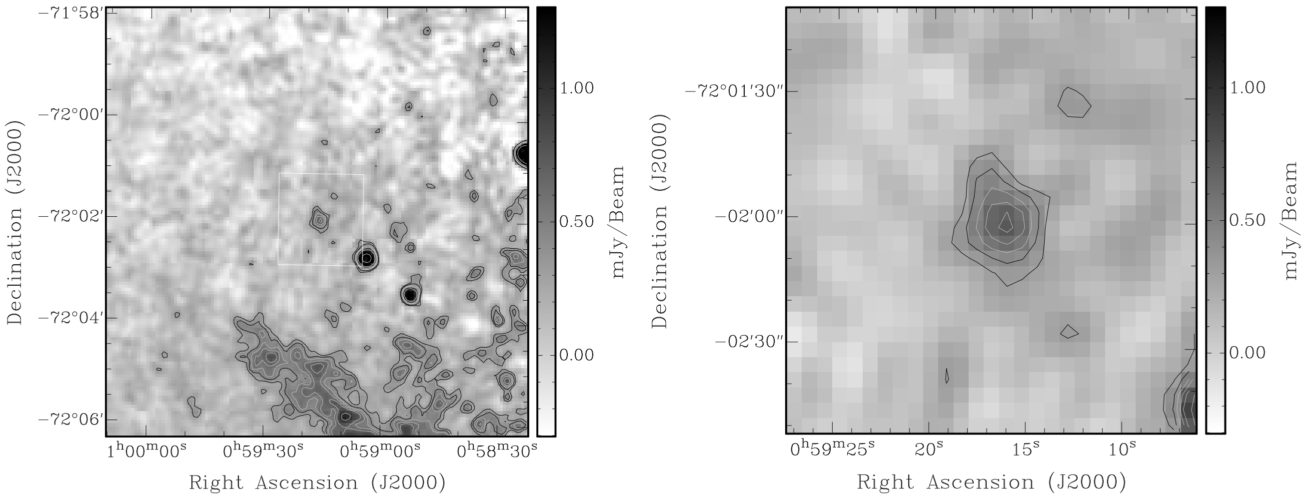

Fig. 1. *A radio-continuum total intensity images of SMP 24 overlaid with contours at: 0.3, 0.4 (black), 0.5, 0.6, 0.7, 1 and 2 mJy (grey). The white box in the left panel indicates the zoom region which is presented on the right. The beam size is shown in the bottom left corner of each of the images.*

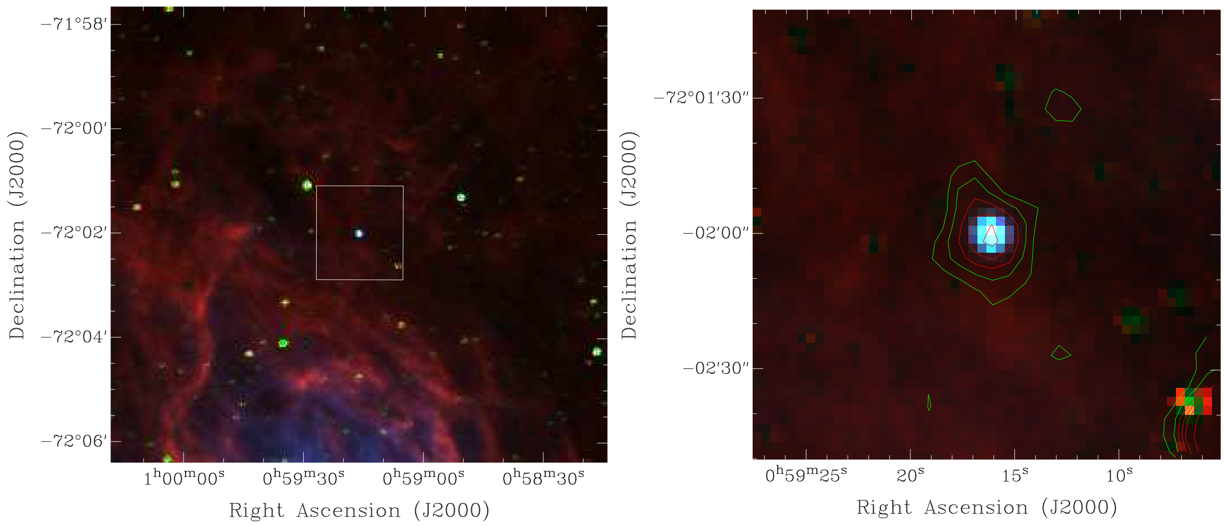

Fig. 2. *Colour composite (RGB) images of the SMP 24 region with Hα in green, [O III] in blue and [S II] in red, and with arbitrary intensity scaling.* **Left***: The 8×8 arcmin region of the SMC where SMP 24 is located. The PN can be seen in the centre of the field as a distinctive blue point source. The white box indicate the "zoom" region which is presented on the right. The part of the star forming region N 66 can be seen to the South of the PN.* **Right***: A radio-continuum contour map of SMP 24 superposed on the MCELS colour composite image. Contours are at: 0.3, 0.4 (dark green), 0.5, 0.6, 0.7, 1 and 2 mJy (red).*

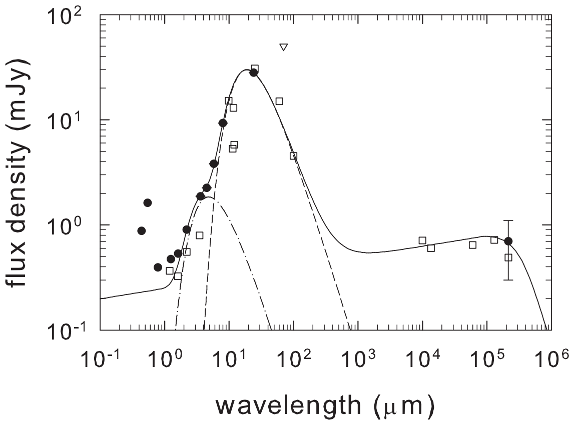

Fig. 3. *SED of SMP 24 from B band to radio frequencies. Dashed line represents the best fit to the FIR band with the black body (BB) approximation. The dot-dashed line represents the best fit (BB approximation) to the empirical distribution in NIR and MIR bands. The summed SED of the radio-continuum, dust and the hot dust is plotted with solid line. The triangle represents the detection limit in the 70 μm band. Overplotted boxes represent the observed SED of a young Galactic PN IC 418, scaled to the distance of the SMC (see text for more details).*

SMC SMP 24: **НОВА РАДИО ПЛАНЕТАРНА МАГЛИНА У МАЛОМ МАГЕЛАНОВОМ ОБЛАКУ**

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UDK ...
Оригинални научни рад

У овој студији представљамо нове ATCA резултате посматрања у радио-континуму ванталактичке планетарне маглине: SMC SMP 24. Нова радио посматрања су конзистентна са посматрањима на осталим таласним дужинама и параметрима нађеним у досадашњим истраживањима. SMC SMP 24 је највероватније млада и компактна планетарна маглина, оптички непробојна на фреквенцијама испод 2 GHz.