

Optical identification of the 3C 58 pulsar and its wind nebula

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We performed deep broadband imaging of the 3C 58 field to detect the optical counterpart of the pulsar and its wind nebula. The imaging was carried out in the U , B , V , R , and I optical bands with the Nordic Optical Telescope and the 6-meter Telescope of the Special Astrophysical Observatory. We have also analyzed the archival images of the field obtained with the Chandra/ACIS and the HRC in X-rays and with the Spitzer/IRAC in the mid-infrared. We detect a faint extended elliptical object whose peak brightness position is consistent at the sub-arcsecond level with the X-ray position of the pulsar. The morphology of the object and the orientation of the major axis are in excellent agreement with the torus region seen almost edge-on in the X-rays, although its size is only about a half of the X-ray size. This suggests that in the optical we see only the brightest central part of the torus nebula. Also, we identify the object in all broadband mid-infrared archival images obtained at 3.6, 4.5, 5.8, and 8 μm , where it has the similar morphology as in the optical range. We do not resolve any point-like source within the nebula that could be identified with the pulsar and estimate that the contribution of the pulsar to the observed optical flux is $\lesssim 10\%$. Using the archival Chandra/ACIS-S data, we analyse the spectrum of the pulsar+nebula X-ray emission extracted from the spatial region identical to the optical/infrared source position and size. We find that a single absorbed power-law provides an acceptable spectral fit. Combining this fit with the optical and infrared fluxes of the detected candidate counterpart, we compile a tentative multiwavelength spectrum of the central part of the pulsar nebula. Within the uncertainties of the interstellar extinction towards 3C 58, it is reminiscent of either the Crab or the PSR B0540–69 wind nebula spectra. The position, morphology and spectral properties of the detected source suggest it to be, indeed, the optical/mid-infrared counterpart of the pulsar wind nebula system. This makes 3C 58 the third (after the Crab pulsar and PSR B0540–69) member of such a system identified in the optical and mid-infrared.