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Magnetic fields of the W4 superbubble

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Many superbubbles and supershells exist in our Galaxy. [1,2,3] They are created by multiple supernova explosions and/or energetic stellar winds from OB star clusters. Superbubbles/supershells can be traced in multi-wavelength, e.g., HI, Hα, X-ray, infrared, and radio polarization. When breaking up on top, they form conduits transferring mass, energy, momentum, and magnetic flux from disk to halo. [4] During the formation and evolution of these large bubbles/shells, magnetic fields are believed to have strong influences.

W4 superbubble is a prominent structure with 150 pc in width and 270 pc in height. The age of the W4 superbubble is inconclusive, being arguably 6.4 – 9.6 Myrs [5] and 2.5 Myrs. [6] It has been also puzzled that why the shells of the W4 superbubble so collimated and why such elongated structure out of the plane does not fragment. Numerical models indicate that magnetic fields should exist to maintain the collimation of the shells and suppress the instability to break the bubble up. [7] In addition, magnetic field is also a key parameter for age estimate in simulations.

New sensitive radio total intensity and polarization observations are made at 6 cm with the Urumqi 25-m telescope and at 11 cm with the Effelsberg 100-m telescope to study the magnetic fields of the W4 superbubble. The thermal nature is proved by the derived flat continuum spectrum indicating that W4 superbubble does not emit in polarization, but acts as a Faraday screen which modulates the background polarization passing through it. With the model of Sun et al (2007), [8] we determine the thermal electron density $n_e = 1.0/(f_{ne})^{1/2}$ cm^{-3} and the strength of the line-of-sight component of the magnetic field $B_{//} = -5.0/(f_{ne})^{1/2}$ μG (i.e., pointing away from us) in the western shell of the W4 superbubble, where f_{ne} is the filling factor of thermal electrons. Taking the geometry into account, [9,10] the total magnetic field B_{tot} in the western shell exceeds 12 μG. The thermal electron density and magnetic field are lower and weaker in the upper part of the superbubble. The rotation measure is found to be positive in the eastern and negative in the western shell of the superbubble, consistent with the picture that the magnetic field in the Perseus arm is lifted by the expansion of the bubble. The results derived in this work for the W4 superbubble provide important inputs for numerical simulations and evolution models of superbubbles breaking out of the Galactic plane.

References
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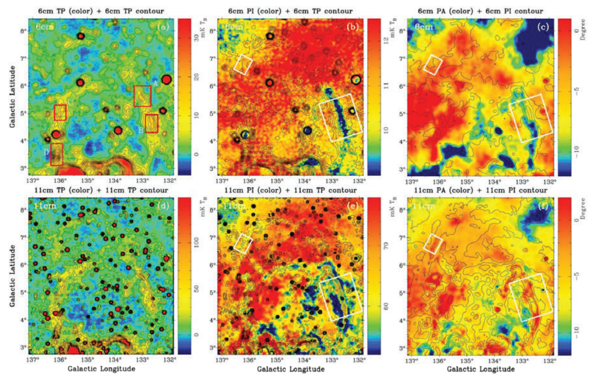

Figure 1. images of the total intensity *I*, polarization intensity *PI*, and polarization angle *PA* at 6 cm (upper panels) and at 11 cm (lower panels). Data in the red rectangles are used for spectrum derivation and in the white rectangles are used for the Faraday screen model.

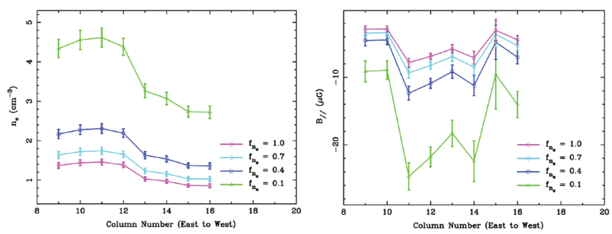

Figure 2. thermal electron density (left panel) and the strength of the line-of-sight component of magnetic field $B_{//}$ (right panel) across the western shell of the W4 superbubble for different thermal electron filling factors.