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On Synthetic Measurements of Large-Scale Turbulent Magnetic Field Nature in Supernova Remnant: the slope of magnetic energy spectrum

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Write abstract in 10pt

Galactic cosmic-rays (CRs), which range in less than $10^{15.5}$ eV (e.g., [1]), are expected to be accelerated in supernova remnants (SNRs). The most acceptable theory of the CRs acceleration known as diffusive shock acceleration ([2, 3]) assumes that the accelerated particles are scattered by turbulent magnetic field (e.g. Alfven waves). The essential nature of CRs, which is maximum energy of CRs and the energy spectrum realized in SNR, is significantly affected by the turbulent magnetic field properties. However, the magnetic field nature is most unsettled issue in the SNRs.
Polarized synchrotron measurements can provide valuable information on the magnetic field. Radially oriented magnetic field in young SNRs is good example (e.g., [4]). At the contact discontinuity between supernova ejecta and shocked interstellar medium (ISM), the growth of Rayleigh-Taylor instabilities (RTI) can generate the radially oriented magnetic field because the RTI-driven turbulence is radially biased (e.g., [5]). However, the radial magnetic field orientation is observed even in the region just behind the shock, where RTI does not work. Many authors have considered an amplification of the magnetic field in the region adjacent to the shock (e.g., [6-10]). For instance, using three-dimensional magnetohydrodynamic (MHD) simulation, Inoue et al. (2013, [7]) showed that in the region just behind the shock, the radially biased turbulence is driven by the interaction between the shock and preexisting upstream density fluctuation in the ISM (e.g., [11]) which is known as Richtmyer-Meshkov instability (RMI), and that the synthetic polarized synchrotron emission based on the simulated turbulent magnetic field can reproduce the above polarization observations.
It is believed that the synchrotron polarization measurements in SNR bring us direct properties of turbulent magnetic field. Indeed, concerning the spectral index of turbulent magnetic field, Lazarian & Pogosyan (2016, [12]) suggested that the property of MHD turbulence can be studied by analyzing two-point spatial correlation of the polarized synchrotron intensity in ISM. This suggestion is numerically confirmed by [13] and [14] for synthetically reproduced turbulent magnetic field in cubic domain. However, the SNR has a spherical, shell-like geometry, which affects the observed polarization properties. Furthermore, there can be multiple types of magnetic field fluctuations driven independently by different mechanisms as discussed above. In this presentation, by analyzing a turbulent spherical shell model, which contains two statistically independent magnetic field fluctuations, we show that the spectral slope of the turbulent magnetic field can be measured by future observations of young SNRs.
We find that the correlation on the concentric circular-arc of the SNR projected on the sky can recover the spectral slope of the given magnetic field, which suppresses greatly the geometrical effect of SNR shell.

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