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Special Topic: Peering into the Milky Way by FAST

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The diffuse ionized gas in the Milky Way galaxy

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Existence of a warm (10^4 K), diffuse (0.1 cm^{-3}), ionized gas component in the Galactic disk in our Milky Way was first suggested by Hoyle and Ellis [1] based on low frequency radio continuum observations. Further studies, primarily using Hα emission as a tracer, revealed that this diffuse ionized gas (DIG) is a major component of the interstellar medium, making up to ~20% of the total Galactic gas mass and more than 90% of the ionized gas in the Milky Way galaxy [2]. Because of extinction from dust, however, optical studies of the DIG using Hα are mostly limited to regions near the Sun and do not probe the inner Galaxy, where most of the massive star formation resides. Moreover, the relatively low spatial and spectral resolution of most Hα surveys cannot separate DIG emission from H II regions, discrete zones of ionized gas surrounding young, massive stars. The dispersion of radio waves from pulsars provides an extinction-free probe of the DIG if the distance can be independently determined. Pulsar dispersion measures, however, only provide a sparse sampling of the DIG and have significant uncertainties [3].

The DIG was discovered over 50 years ago but there remain significant questions about its origin, distribution, and characteristics. Recently, a new tool has been used to explore the DIG: radio recombination lines (RRLs), electronic transitions at high principal quantum numbers (n~100) with energies detected at radio wavelengths. RRLs penetrate dust in the Galactic Plane and therefore can be used to trace DIG emission throughout the Milky Way galaxy. The disadvantage is that they are much weaker than Hα emission. Recent advances in radio spectrometers, however, have allowed many RRLs to be observed simultaneously and therefore averaged or stacked together to increase the sensitivity. Observations of RRLs with the Green Bank Telescope (GBT) provided the first sensitive survey in the Galactic disk with sufficient angular resolution to separate DIG emission from H II regions [4]. Preliminary results indicate that the source of the DIG emission is from ionizing stars near H II regions [5].

In the current issue, Hou et al. [6] make a new RRL survey of the DIG using the Five-hundred-meter Aperture Spherical radio Telescope (FAST). The RRL observations are taken simultaneously in a piggy-back mode with the Galactic Plane Pulsar Snapshot (GPPS) survey [7]. This GPPS RRL survey is the most sensitive survey to date and has sufficient angular resolution to separate DIG emission from H II regions, which is enabled by the large single-dish aperture of the FAST and the 19-beam receiver that significantly increases the survey speed. When complete the GPPS RRL survey will sample the Galactic Plane visible to the FAST within ±10° in Galactic latitude for a total sky area of about 2500 square degrees. The GPPS RRL survey will therefore be able to better characterize the DIG by measuring the distribution, ionization state, and turbulent motions of the ionized gas over a larger area and with better sensitivity.

Future instruments that are planned or under construction, such as the Square Kilometer Array (SKA), are interferometers and therefore are not sensitive to the diffuse, extended

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emission arising from the DIG. Large single-dish telescopes such as the FAST are the best to probe the DIG, the last major component of the Milky Way galaxy to be well characterized.

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