7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Peering into the Milky Way by FAST: Ionized gas in the Galactic disk revealed by the piggyback line observations of the FAST GPPS survey

L.G. Hou [1] , J.L. Han [1,2] , Tao Hong [1] , X.Y. Gao [1,2] and Chen Wang [1]
[1] National Astronomical Observatories, Chinese Academy of Sciences,
[2] School of Astronomy, University of Chinese Academy of Sciences
e-mail (speaker): lghou@nao.cas.cn

Ionized gas, is one of the major components of the Galactic interstellar medium. It is widely distributed in the Milky Way, accounting for about 20% of the total gas mass [1]. However, the ionized gas in the Milky Way, especially the low-density diffuse component, has not yet been well revealed in the radio band, awaiting to be observed with a much improve sensitivity, spatial resolution, spectral resolution, and sky coverage.

The Galactic Plane Pulsar Snapshot (GPPS) survey is an on-going pulsar hunting project made with the Five-hundred-meter Aperture Spherical radio Telescope (FAST) [2], currently the largest single-dish telescope in the world with a 300 m illumination aperture. The GPPS survey has successfully discovered more than 600 pulsars (see *http://zmtt.bao.ac.cn/GPPS/*) by using the 5 minutes integration of each pointing by using the *L*-band 19-beam receiver that has a system temperature of 22 K. The GPPS survey is to make the most sensitive systematic search for radio pulsars within the Galactic latitude of ±10° around the Galactic plane visible by FAST. During the pulsar survey observations, the piggyback spectral line data in the *L*-band of 1000—1500 MHz are recorded simultaneously with the digital spectroscopy backends connected to the *L*-band 19-beam receiver, providing the most sensitive spectra for more than 150 radio recombination lines (RRLs) from the elements of Hydrogen (H), Helium (He), Carbon (C) and Sulfur (S) etc.

The data processing pipeline for the H$n\alpha$ RRLs have been developed by the research team. The first paper [3]publish the results in a pilot sky area of 88 square degrees in the inner Galaxy of $33° \leqq l \leqq 55°$ and $|b| \leqq 2.0°$ (Figure 1). The spectral data of the H$n\alpha$ RRLs have a spatial resolution of about 3 arcminutes, a spectral resolution of 2.2 km s^{-1}, and a typical spectral RMS noise of 0.25 mJy $beam^{-1}$ or 6.3 mK in the main-beam brightness temperature. The piggyback H$n\alpha$ RRL observations of the FAST GPPS survey are sensitive down to an emission measure of about 200 $cm^{-6}pc$ for the Galactic interstellar ionized gas at the 3σ detection limit. From the first H$n\alpha$ RRL map of the observed sky area, we find complex structural features dominated by a number of HII regions as well as extended ionized gas regions. We detect about 94% of the known HII regions, and confirm 43 WISE candidates as HII regions. Several large HII regions or star-forming complexes in the distant outer Galaxy are resolved by the FAST observations of H$n\alpha$ RRLs. Extended RRL features of the low-density diffuse ionized gas are detected. In addition, the piggyback spectral line data of the GPPS project also provide sensitive observations for other kinds of RRLs at *L*-band, such as the He$n\alpha$, C$n\alpha$, S$n\alpha$, H$n\beta$ and H$n\gamma$ RRLs, which will be gradually processed and released on the project web-page: *http://zmtt.bao.ac.cn/MilkyWayFAST/*.

As the most sensitive survey for RRLs at *L*-band to date, together with good spatial resolution, spectral resolution and large sky coverage, the piggyback spectral data of the FAST GPPS survey will promote our understanding of the properties of ionized gas in the Milky Way.

References

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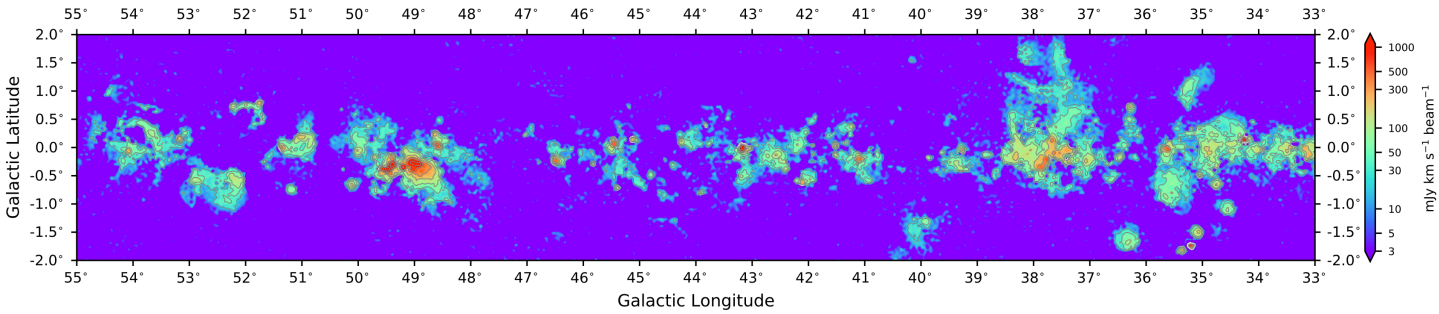

Figure 1. Velocity-integrated intensity map of the H$n\alpha$ RRLs recorded by the FAST GPPS survey for the inner Galactic plane of $33° \leqq l \leqq 55°$ and $|b| \leqq 2.0°$. The observation beam has a size of about 3 arcminutes. The velocity range for the integration is from V_{LSR}= −40 km s^{-1} to 120 km s^{-1}. The overlaid contour levels are at $2n \times 5$ mJy km s^{-1} $beam^{-1}$, with n = 2, 3, ..., 10.