Beyond the IGPS - Future Radio Surveys of the Galactic Plane

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ABSTRACT

There are strong scientific motivations to continue and expand radio frequency surveys of the plane of the Milky Way. More immediately, surveys in the far infra-red and X-ray bands urgently need radio maps for comparison. Beyond the International Galactic Plane Survey (IGPS), we should be thinking about continuum surveys at higher frequencies, recombination line surveys, and molecular line surveys all done with aperture synthesis mosaics combined with single dish observations. To do these surveys we need compact, centrally-condensed antenna configurations, spectrometers with huge numbers of channels, and new generations of computers for data reduction and analysis.

Scientific Motivation

The long term scientific objectives which motivate radio surveys of the Galactic plane are centered on the process of galaxy evolution and the structure of the interstellar medium. As extragalactic astronomy and cosmology push closer to an understanding of how galaxies form in the beginning, Galactic astronomy is challenged to provide a detailed physical description of how the Milky Way has gotten from that primordial state to its present condition. One key to this is an understanding of the full cycle of star formation and feedback into the interstellar medium. Figure 1 sketches this cycle, with stellar processes on the left and interstellar processes on the right.

The specific goals of Galactic plane surveys are to find and measure all sites of active star formation, using the emission from their ionized gas, and to find all supernova remnants (SNR's) younger than some 10^4 years old. Older SNR's are harder to distinguish from the diffuse continuum emission of the Galactic disk, but they provide structure in this diffuse emission on all scales.

Sensitivity and Telescope Time

The three low latitude surveys of the λ21-cm line which have made use of combined single dish and mosaiced interferometer data are the Canadian Galactic Plane Survey (CGPS) [1], the Southern Galactic Plane Survey (SGPS) [2,3], and the VLA Galactic Plane Survey (VGPS) [4,5]. Together we refer to these as the International Galactic Plane Survey. They have all come close to sensitivity of 1 K rms with velocity resolution of 1 km s^{-1} and angular resolution (FWHM) of 1', but with quite different instrumental limitations. We hope to continue all three of these surveys to cover larger areas and to get higher resolution and sensitivity.

For future surveys at higher frequencies we need more compact arrays, like the proposed VLA E-array [6]. Figure 2 shows how this would increase mapping speed. The ultimate instrument for this kind of work will be the Square Kilometer Array (SKA) [7]. Galactic plane surveys may be one of the important scientific applications to justify the SKA. The case becomes particularly compelling if we see radio surveys as complementary to surveys in the X-rays with XMM-Newton and in the infrared with SIRTF [8].

GLIMPSE - The Next Far-IR survey of the Galactic Plane

The greatest advance in mid-infrared astronomy in a decade will be the launch of NASA's Space Infra-Red Telescope Facility (SIRTF) early in 2003. This observatory will not do an all sky survey, but as part of the Legacy Science program it will do a survey of the Galactic plane in the first and fourth quadrants. This survey, the Galactic Legacy Infra-red Mid-Plane Survey Extraordinaire (GLIMPSE), will cover some 200 square degrees with resolution of 2" in four bands

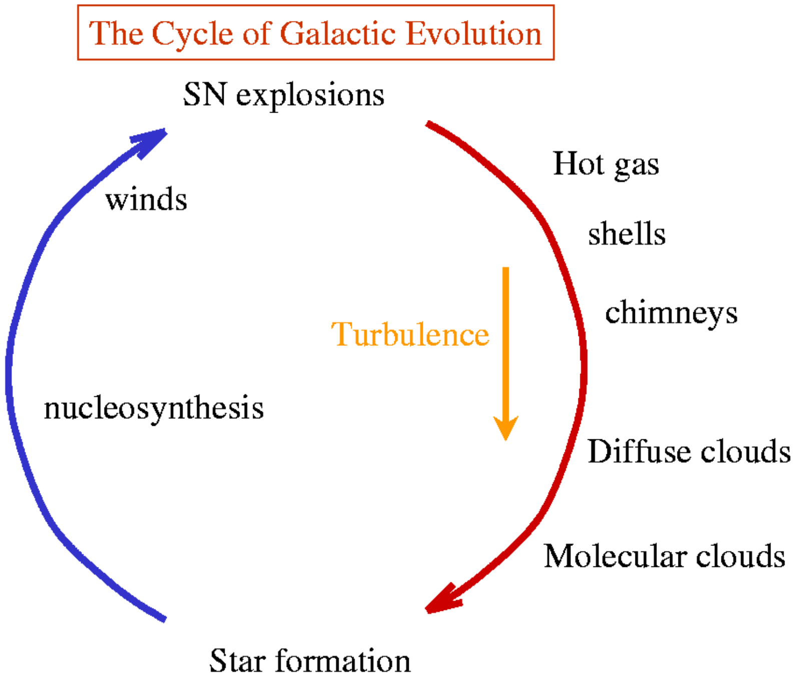

Figure 1: The cycle of Galactic evolution and chemical enrichment. Star formation is at the bottom, and stellar winds and supernova explosions are at the top. We know a great deal about processes on the left side of this diagram that are associated with stellar evolution and nucleosynthesis. We are relatively ignorant of the physical processes that drive material down the right hand side through the interstellar medium back to the next generation of stars. One of the objectives of radio surveys of the Milky Way is to illuminate conditions and dynamics in the various phases of the interstellar medium.

from 3.6 to 8 μm with sensitivity better than 400 μJy rms. The expected number of detected objects is a few times 10^7, of which most will be stars and star formation regions throughout the inner Galaxy.

To identify the regions of ionized gas in the GLIMPSE survey, and to provide kinematic distances, surveys in molecular lines and hydrogen recombination lines will be very valuable. It will be particularly important to do these in the Southern Hemisphere, where existing survey data is less extensive than in the North. Mosaic surveys of sub-areas with the Australia Telescope National Facility (ATNF) in the NH_3 line will be a top priority. A recombination line survey of the fourth Galactic quadrant at λ11-cm would be very valuable.

SUMMARY

Surveys of the Galactic plane with new and existing telescopes are among the most productive observational programs. At centimeter-waves these surveys are relatively easy to do from the ground, whereas in the mid-infrared and X-ray bands it is enormously more costly and difficult. In the last decade we have made a start with the CGPS, SGPS, and VGPS surveys. Now we are ready to plan and prioritize the next campaign in this international effort.

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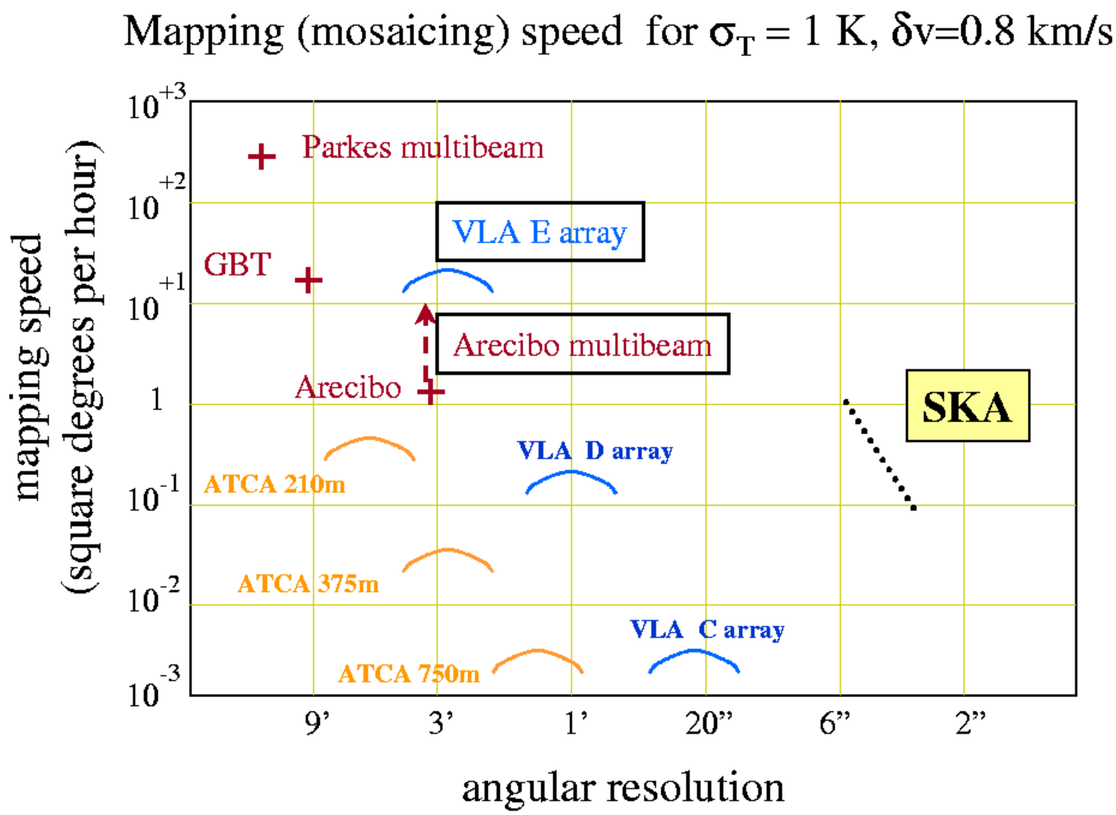

Figure 2: Mapping speed (the inverse of telescope time) vs. angular resolution for a fixed brightness sensitivity for surveys of the λ21-cm line. The minimum latitude coverage for a survey of the inner galaxy like the SGPS or GLIMPSE is $\pm 1^o$ latitude and $\pm 60^o$ or more of longitude, say 250 square degrees. The VGPS covered less than half that area with the D array, with total telescope time of about 275 hours. The planned E array of the VLA could have done it in less than two days, but with lower angular resolution.

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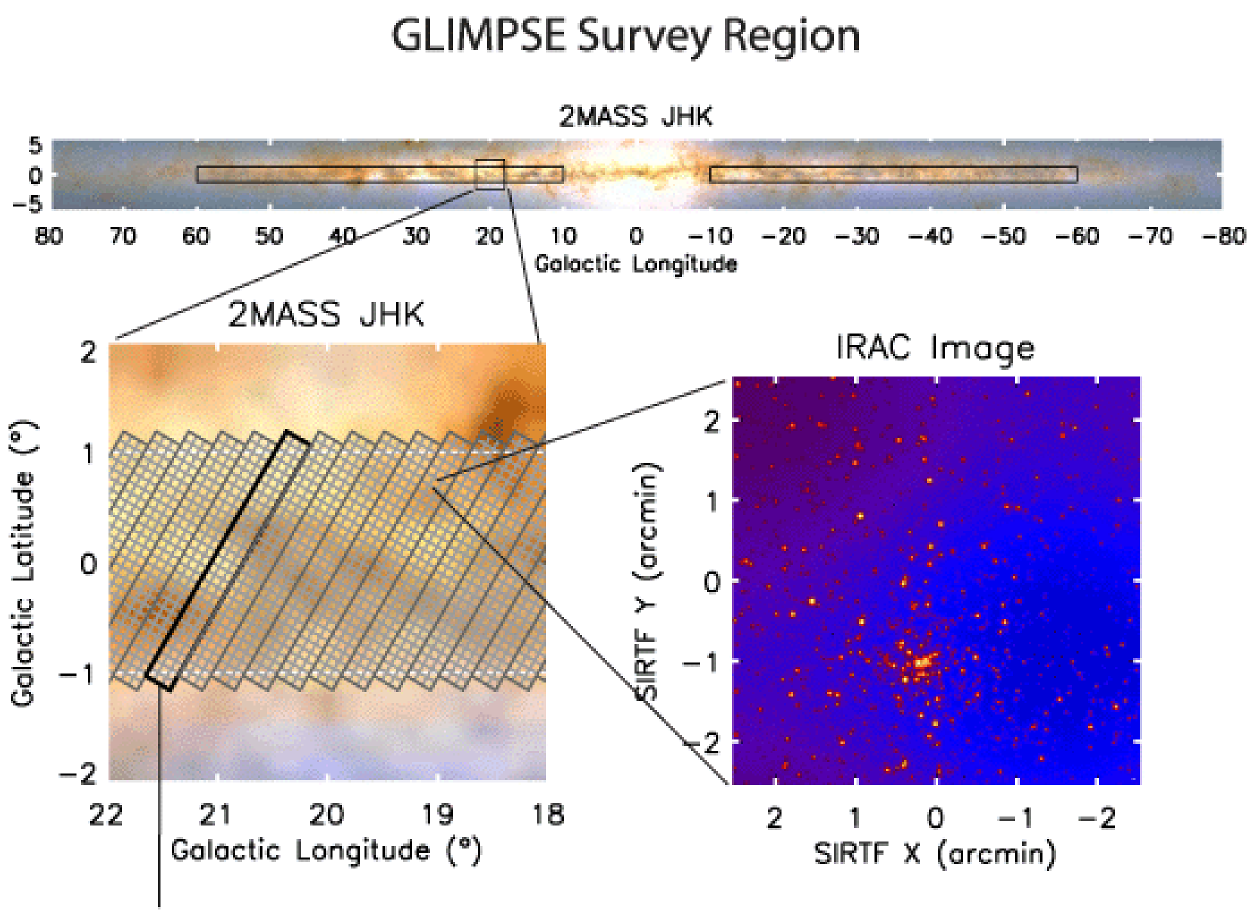

Figure 3: The GLIMPSE survey region, with some simulated data to illustrate the amazing improvement in resolution and sensitivity over existing survey data.