Brackett-□ line survey of the ionized hydrogen in the Galactic plane

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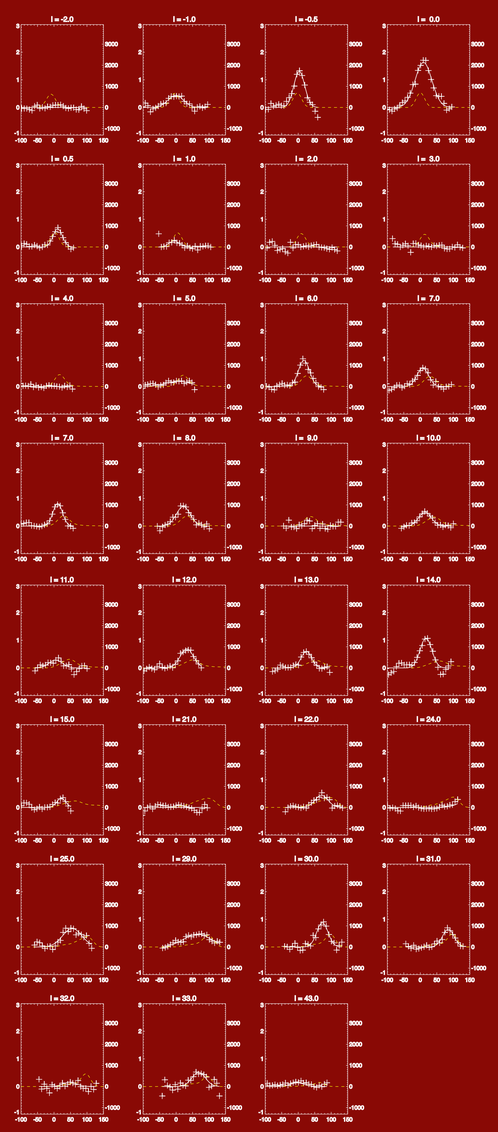
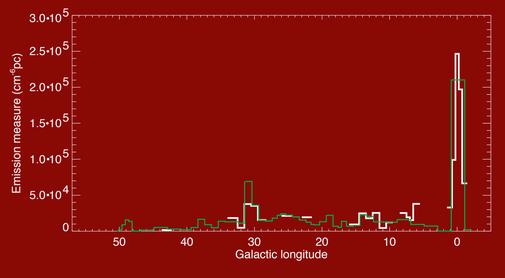


Emission line spectra of the observed fields in the Galactic plane. Intensity scale for each graph is given in units of 10^-6 erg s^ -1 cm^ -2 sr^ -1 (left axis) and emission measure cm ^ -6 pc , integral per bandpass (right axis). Data represented by crosses with a least square fit by Gaussian (white line). Dashed yellow line is the result of model spectrum from the diffuse intercloud ionized medium based on Taylor and Cordes (1993) free electron distribution in the Galactic plane.

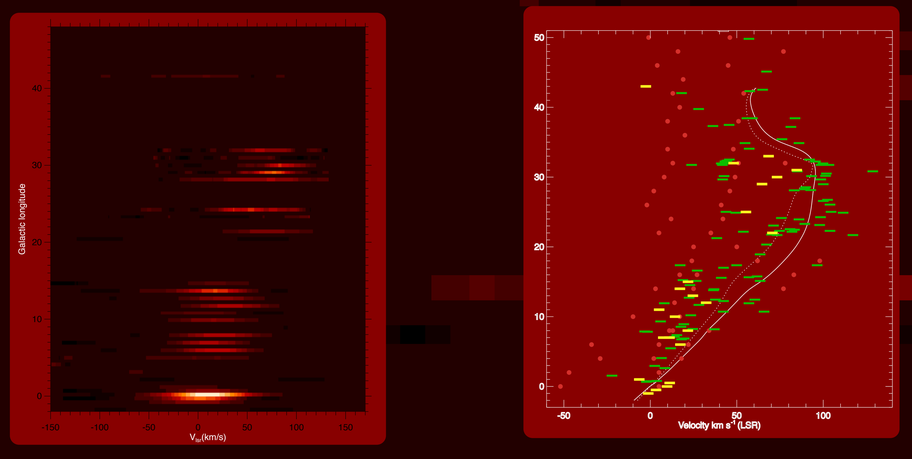


Emission measure versus galactic longitude derived from Brackett-gamma, H166-alpha Lockman (1976) Brackett-gamma data shown with white line, H166-alpha -- green line. Brackett-gamma were corrected for extinction using kinematic distances and assuming uniform distribution of the extinction A(K)=0.32 per kpc. We also reduced Brackett-gamma data to the H166-alpha field of view (20') aasuming that most of the emission is coming from within H166-alpha survey field of view.

ABSTRACT

We report on the first results of a pilot program to carry out a 2.1655 □m Brackett-gamma (Br-□) hydrogen recombination emission line survey of the Galactic plane. The primary goal of this study is to explore the global morphology and energy balance of the warm ionized component and its relation to the other phases of the interstellar medium (ISM). Unlike the neutral components, the warm ionized component of the ISM (which accounts for most of the HII mass in the Galaxy) has remained virtually unexplored on large scales. A survey in the Br-□ line offers distinct advantages over traditional optical lines studies, such as H-alpha, since Br-□line is much less affected by the extinction and allows to see through the obscuring dust in the Galactic plane.

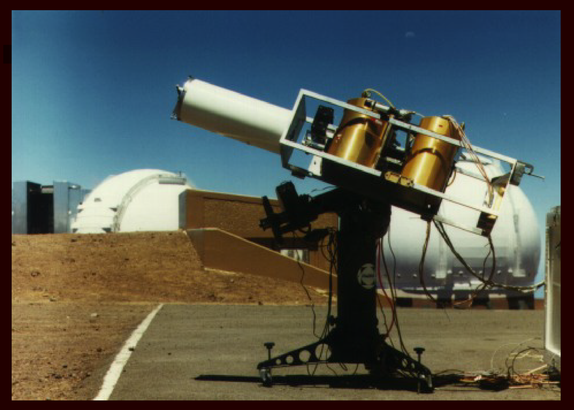
The observations have been carried out using a Goddard-Wisconsin cryogenic Fabry-Perot spectrometer with a 256x256 InSb detector. This instrument was specifically designed to study diffuse component of the emission. Its resolving power is 10^4, the field of view is 1^o, and the instantaneous velocity range is 200 km/s. For this survey fields were selected in 1^o steps along the Galactic plane from -2^o to 43^o longitude. The velocity range of the observed emission features ranges from -10 km/s to 90 km/s (LSR). Typical detected intensities correspond to emission measures of ~10^3 cm^{-6} pc. Detected intensities show great variation on a scale of 1^o or less and can be considered as an additional evidence of extremely clumpy structure of the interstellar gas in the inner Galaxy. The emission scaleheight and Lyman continuum luminosity of the Galactic Center region has been estimated N(Lyc)=3.9x10^{51} photons/s.

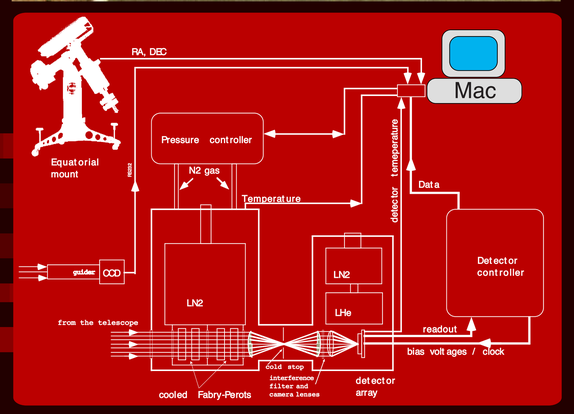


V elocity-longitude map (left) of the detected Brackett-gamma emission. Brightest emission detected toward the Galactic center corresponds to emission measure of about 2000 cm^-6 pc. Velocity - longitude diagram (right) for Brackett-gamma, Lockman et al. (1996) radio recombination line data on 130 diffuse distant HII regions and H-alpha surveys Reynolds (1983). Brackett-gamma detection are shown as yellow rectangles, Lockman RRL data - green rectangles, Reynolds (1983) H-alpha - red circles. Lines represent modeled velocity of the peak of the emission profile without (solid line) or with (dotted line) extinction. Extinction value accepted in the model is 0.32^m per kpc in K band. Electron density distribution n_e was accepted from Taylor and Cordes (1993) PSR study.

Results and further development

- A number of fields has been detected in this survey of the inner part of the Galaxy. Detected intensities show great variation on a typical scale of 1 degree or less, and this can be considered as additional evidence of an extremely clumpy structure of the interstellar gas in the inner Galaxy.
- The observed velocity pattern of the detected Br-gamma emission generally follows that of RRL survey and the model of the electron density distribution expected from the modeling of the diffuse warm ionized gas.
- The measured intensity of the Brackett-gamma line toward the Galactic Centre gives an integral production rate of Lyman continuum photons in the region surrounding Galactic Centre are in good agreement with estimates based on the far-infrared and radio data. However the Galactic Centre is a special case, where the distance to the emitting region is known and extinction measurements are available, which allows reliable quantitative estimates of the emission line intensity corrected for extinction.
- For most of the observed fields however, reliable estimates of the energetics of the HII component are unavailable at this stage of the survey. To complete the picture and obtain reliable data on energy balance of the ISM, the Brackett-gamma survey must be completed and an identical survey needs to be carried out in the hydrogen Brackett-alpha line as well.
- All the fields observed in the Brackett-gamma survey will also be observed in Brackett-alpha. With both surveys completed a reliable correction for extinction will be possible and therefore reliable measurements of intensities corrected for extinction will be obtained. As a by-product of the survey, a large scale Galactic extinction maps will be created. Measured Brackett line intensities will allow accurate estimates of the Lyman continuum luminosity of OB star population in the inner Galaxy and will be essential for verification of the models of the massive star formation in the inner Galaxy.





Block-diagram of the spectrometer. Data acquisition, Fabry-Perot pressure control and equatorial mount tracking are performed by Macintosh computer with National Instruments boards used as interfaces. Small 20 cm in diameter telescope is used as feeding optics for the spectrometer. Spectrometer operated in non-imaging mode when primary mirror and interference pattern is imaged onto the detector. Color photo -- spectrometer setup during observing run by the IRTF Observatory at Mauna Kea, Hawaii.

Intensities and velocities of the detected Brackett-gamma emission along the Galactic plane

Galactic longitude	EM [a]	V(LSR)	□V (FWHM)	D [b] (kpc)	EM_c [c]
-2.0	< 300	--	--	--	--
-1.0	550.0	-1	55	8.5	6680
-0.5	1630.0	3	39	8.5	19810
0.0	2040.0	10	60	8.5	24790
0.5	820.0	11	33	8.5	9960
1.0	270.0	-6	36	8.5	3280
2.0	< 300	--	--	--	--
3.0	< 300	--	--	--	--
4.0	< 300	--	--	--	--
5.0	< 300	--	--	--	--
6.0	1180.0	17	40	4.0	3820
7.0	830.0	8	42	2.1	1540
7.0	1020.0	11	34	2.2	1950
8.0	880.0	22	50	3.6	2530
9.0	< 300	--	--	--	--
10.0	630.0	14	45	2.3	1240
11.0	360.0	5	48	0.8	460
12.0	860.0	32	47	3.7	2550
13.0	750.0	25	38	3.0	1810
14.0	1350.0	17	42	2.1	2500
15.0	420.0	22	32	2.8	960
21.0	< 300	--	--	--	--
22.0	550.0	71	47	4.3	1950
24.0	< 300	--	--	--	--
25.0	840.0	55	69	3.2	2150
29.0	580.0	65	99	3.4	1570
30.0	1090.0	73	41	4.0	3530
31.0	800.0	85	41	5.3	3800
32.0	230.0	48	49	3.0	560
33.0	640.0	68	49	3.6	1840
43.0	260.0	-3	30	0.0	260

(a) Emission measure in (cm^-6 pc) derived from the Brackett-gamma intensities assuming T_e =8000 K.
(b) Kinematic distances
(c) Emission measure corrected for extinction assuming A_K=0.32 per kpc.

References

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