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Ionization of extended low-density warm ionized medium, HII regions and helium radio recombination line from the inner Galaxy

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Abstract. Hydrogen and helium radio recombination line observations using Westerbork Synthesis Radio Telescope along 28 different directions from the inner Galaxy have been presented. These observations at ~1.4GHz have resulted in detection of 57 hydrogen RL components and some of these (13) have an associated helium RL. The results of correlation of helium RL detection with HII regions and distance to the line originating ionized gas cloud in the form of a weigh scheme for 11 positions from this sample have already been published in a previous paper. Here results obtained from an additional set of 17 new positions have been combined with the previous set. In total 26 cases of hydrogen RL components have either a detection or a non-detection of associated helium RL (13:13) with a detection confidence factor greater than 1.0. These 26 cases further belong to a selected subset of 40 hydrogen RL from the 57. The remaining 14 from the 40 have detection confidence factor less than 1.0 and hence require more data or a better spectrum to ascertain their implication. The 26 hydrogen RL segregate as expected under the HII region correlation weigh scheme with a difference of a factor of 10 between the expected weight for a detection from a non-detection. All the He RL non-detection cases are found to have a correlation weight less than the 85% of the He RL detection cases. From this weigh scheme it is proposed that ionization of ELDWIM is directly related to near by HII regions. The ionization spectrum being hot or cold depends on the presence of near by HII regions which supply the required ionization photons. This is reflected in the occurence of an associated helium RL with the hydrogen RL, as the first ionization potential of helium (24.6 eV) is nearly twice that of hydrogen (13.6 eV). On the other hand ELDWIM can also form the outer envelopes of the near by HII regions or perhaps exists in both the forms.

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1. The weigh scheme

The ratio N_{He+}/N_{H+} when helium is fully ionized is normally accepted as 0.1 (Peimbert et al. 1988; Osterbrock 1989; Baldwin et al. 1991; Reynolds 1995; Heiles et al. 1996b; Gordon & Sorochenko 2002; Madsen et al. 2006; Poppi et al. 2007). Recent estimates (Wenger et al. 2013) of this ratio in Galactic HII regions/nebulae through RRL emission are in the range of 0.045-0.091. In the previous work (Baddi 2011b) a weigh scheme was suggested that associated a correlation weight towards each position or hydrogen RL which represented a helium RL detection measure given by,

$$W = \frac{N_{HII} {D_c}^2}{{D_c}^3 {D_c}^3} \left[\frac{1}{D^2_{1HII}} + \frac{1}{D^2_{2HII}} + \cdots + \frac{1}{D^2_{nHII}} \right] = \frac{N_{HII}}{{D_c}^4} \sum_n \frac{1}{D^2_{nHII}}. \qquad (1)$$

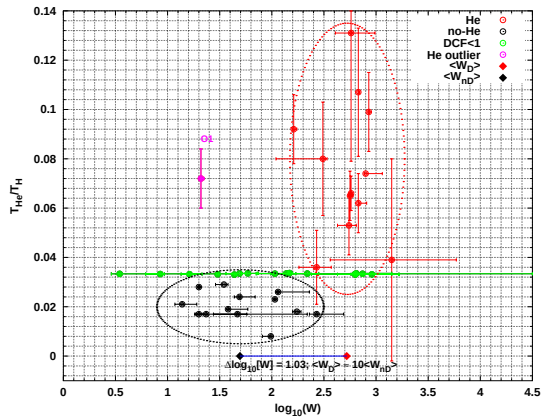

Figure 1. Plot of T_{He}/T_H Vs $\log_{10}$(W) for all the 40 RLs detected from 26 different directions. The difference $\Delta\log_{10}$(W) between the centroids of the weights of detections and non-detections is marked at the bottom of the plot, this turns out to be a factor of ∼10. The outlier O1 can be explained as a case of missing HII regions which are to be taken into account for the true weight, if not a special case of He RL origin. On the other hand further splitting of this component can lead to the change of the weight itself. Cases with DCF<1.0 have their T_{He}/T_H ratio normalized to the expected value σ_e/T_H. The over all observed statistical correlation between helium RL detection and the weights obtained here perhaps suggests that the ELDWIM ionization is effected by photons leaking from the surrounding nearby HII regions. The weight is assumed to take into account both near by and far away solutions. Higher the weight more are the chances of ionization of helium in the medium by these HII regions, irrespective of whether the RL originates in near by or far away Galaxy.

N_{HII} is the total number of HII regions (Paladini et al. 2003; Anderson et al. 2011) within a kinematic distance (Sofue et al. 2009) of 500pc from the near by kinematic RL originating position. D_C is the near by kinematic distance[1] to the cloud from the observer (solar system) and D_{nHII} is the distance of the individual HII regions (all considered with near by solution) from the center of the ELDWIM cloud. The weight is assumed to account for both near by and far away solutions with the HII regions in the periphery of the distribution (Figure 5, Baddi 2011b) contributing only to the near by solution. While only those in the central core are capable of contributing to the far away solution as well.

References

Anderson L. D., Bania T. M., Balser D. S., Rood R. T., 2011, ApJS, 194, 32

Baddi R., 2011b, The AJ, 142:154

Baldwin Jack A., Ferland Gary J., Martin P. G., Corbin Michael R., Cota Stephen A., Peterson Bradley M., Slettebak Arne, 1991, ApJ, 374, 580B

Gordon M. A., Sorochenko R.L., Radio Recombination Lines, Their Physics and Astronomical Applications, Astrophysics and Space Science Library, Vol. 282. Kluwer, Dordrecht, 2002, ASSL, 282

Heiles C., Reach W. T., Koo B.-C., 1996b, ApJ, 466, 191

Madsen G. J., Reynolds, R. J., Haffner L. M., 2006, ApJ, 652:401

Osterbrock D. E., 1989, Astrophysics of Gaseous Nebulae and Active Galaxies, University Science Books, Mill Valley, California

Paladini R., Burigana C., Davies R. D., Maino D., Bersanelli M., Cappellini B., Platania P., Smoot G., 2003, A&A, 397, 213

Peimbert Manuel, Ukita, Nobuharu, Hasegawa, Tetsuo, Jugaku, Jun, 1988, PASJ, 40, 581P

Poppi S., Tsivilev A. P., Cortiglioni S., Palumbo G. G. C., Sorochenko R. L., 2007, A&A, 464, 995

Reynolds R. J., Tufte S. L., 1995, ApJ, 439:L17

Sofue Y., Honma M., Omodaka T., 2009, PASJ, 61, 227

Wenger Trey V., Bania T. M., Balser Dana S., Anderson L. D., 2013, ApJ, 764, 34

[1] Other exponents of D_C like 3 or 2 also produce noticeable segregation.