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The First Detection of Diffuse Interstellar [OII] Emission and Confirmation that Variations in $\alpha$/[OIII] Trace Variations in Temperature

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Observations & Results:
We carried out velocity-resolved observations of the [OII] doublet emission over a region of the sky already mapped by WHAM in [NI] and [OIII]. A series of 10 minutes towards the largest distance sources are interposed with exposures toward high Galactic latitude regions where very little interstellar [OI] emission is expected. This “on-off” technique is used to identify terrestrial emission, which is included in [OI] in addition to other errors; refer to Figure 3. Our observations confirm the superb performance of the SHS technique for measurements of spatially extended faint emissions, including the first detection of [OII] emission originating outside the Milky Way: [OII] from the Galactic equator in the longitude range of 110° to 115° [OII] intensities range from tens of Rayleighs near the Galactic plane to less than one Rayleigh at high Galactic latitudes (Mierkiewicz et al., 2006). The [OII] line profiles clearly show structure indicating emission along the lines of sight from both local interstellar gas and more distant gas Doppler-shifted by different Galactic rotations; refer to Figure 4.

This conclusion is borne out quantitatively. In Figure 5, observations of [NII] are plotted versus [OII] for the low velocity (local) gas components toward 7 diffuse emission regions between l=138° and l=158° with latitudes between $-4°$ and $+4°$ and two bright classical O star HII regions. This plot shows a clear relationship between [OII] and [NII] that closely follows what predicted by variations in temperature (solid line). The solid line in Figure 5 is from the relationship:

\[ \frac{[OII]}{H\alpha} = 9.76 \times 10^{-5} \frac{T}{10^{4}} \]

which are derived assuming standard gas phase abundances and ionization ratios [OII]/Hβ and NII/Heβ that are 1.0 and 0.8, respectively. Because we have not yet carried out an accurate absolute intensity calibration for our [OII] measurements, the curve in Figure 5 has been normalized to [OII] to $H\alpha$ = 0.52, corresponding to a temperature of $7700$ K. The associated temperatures are also plotted.

The excellent correspondence between the variations in the observed line ratios and the relationship predicted by changes in temperature is very convincing evidence, for these data at least, that the line intensity ratios are dominated by variations in temperature within the Named Setup. Not only are [OII] and [NII] both highly correlated with [OIII] enhancement in [OII] is greater than that in [NII], just as predicted if the line ratio variations are due to variations in temperature (the excitation energy for [OII] is significantly higher than that for [NII]).

Limitations on the model presented in this paper are that high ionization gas may be present in some regions, and that certain assumptions may not hold in all cases. For example, if the temperature is constant but the electron density is varying, the line ratio will change. This is a limitation of any model that assumes a single ionization state.

Conclusion:
The detection and study of diffuse interstellar [OIII]3726-9 emission has provided strong evidence that the large variations observed in [NI] and [OIII] intensity ratios are the result of significant (2000–3000 K) temperature variations within the diffuse ionized gas of the Milky Way. The reason for these temperature variations is not yet known.

References:

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