Near-Infrared Spectroscopy of M Dwarfs.
I. CO Molecule as an Abundance Indicator of Carbon

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M dwarfs are the largest stellar group in the solar neighborhood. Because of their small masses, the lifetimes of M dwarfs are longer than the age of the Universe, and M dwarfs are composed of the samples of all the populations including very old ones. Unfortunately, our understanding of this large and rich stellar group is rather poor compared to other stellar groups. This is largely due to the difficulty of observing M dwarfs because of their faintness. Recent progress, however, overcame the observational barriers to some extent, especially in the field of stellar interferometry, infrared spectroscopy, astrometry and photometry from space.

Based on the near-infrared spectra of 42 M dwarfs, carbon abundances are determined from the ro-vibrational lines of the CO(2–0) band. We apply T_{eff} values based on the angular diameters if available or use the T_{eff} values in a $\log T_{\mathrm{eff}} - M_{3.4}$ relation ($M_{3.4}$ is the absolute magnitude at 3.4 μm based on the WISE *W1* flux and the Hipparcos parallax) to estimate T_{eff} values of objects for which angular diameters are unknown.

On the observed spectrum of the M dwarf, the continuum is depressed by the numerous weak lines of H_2O and only the depressed continuum or the pseudo-continuum can be seen. On the theoretical spectrum of M dwarf, the true continuum can be evaluated easily but the pseudo-continuum can also be evaluated accurately thanks to the recent H_2O line database. Then the spectroscopic analysis of the M dwarf can be done by referring to the pseudo-continuum both on the observed and theoretical spectra. Since the basic principle of the spectroscopic analysis should be the same whether the true- or pseudo-continuum is referred to, the difficulty related to the continuum in cool stars can in principle be overcome. Then the numerous CO lines can be excellent abundance indicators of carbon, since almost all the carbon atoms are in stable CO molecules which suffer little effect of the uncertainties in photospheric structure, and carbon abundances in late-type stars can best be determined in M dwarfs rather than in solar type stars.

The resulting C/Fe ratios for most M dwarfs are nearly constant at about the solar value based on the high classical carbon abundance rather than the recently revised lower value. This result implies that the solar carbon abundance is atypical for its metallicity among the stellar objects in the solar neighborhood if the downward revised carbon abundance is correct.

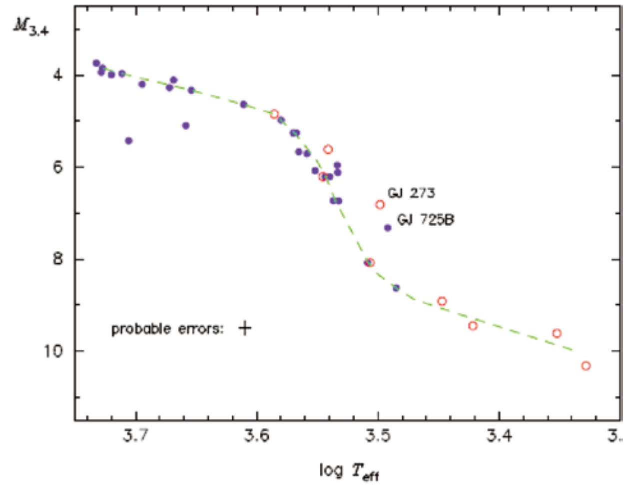

Figure 1: $\log T_{\mathrm{eff}} - M_{3.4}$ relation. T_{eff} values are based on interferometry (blue) or infrared flux method (red).

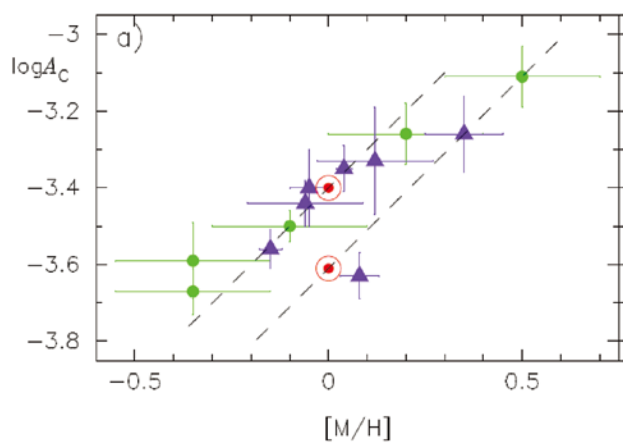

Figure 2: Carbon abundances $\log A_C$ vs. Metallicities obtained by other infrared spectroscopy. The upper(/lower) locus is C/M ratio for the high(/low) solar value (⊙).

Reference

[1] Tsuji, T., Nakajima, T.: 2014, *PASJ*, **66**, 98.