国立天文台天文シミュレーションプロジェクト成果報告書

The chemical structure of protoplanetary disks

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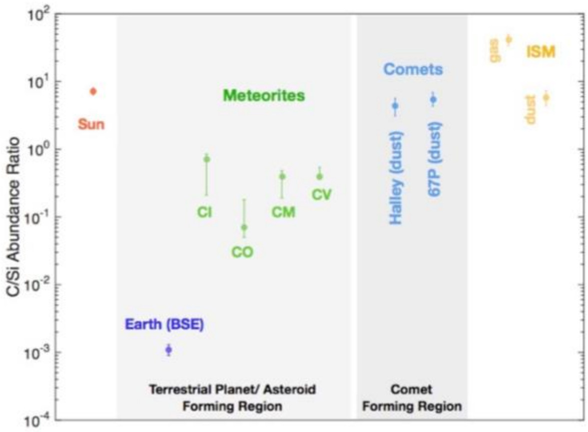

The bulk composition of Earth is dramatically carbon poor compared to that of the interstellar medium, and this phenomenon extends to the asteroid belt. A gradient in the amounts of refractory carbon relative to silicate is shown in our solar system. To interpret the carbon deficit problem, we focus on two issues:

(1) The carbon depletion gradient in the inner solar system. (2) Test the carbon grain destruction observationally.

We assume two kinds of central stars T-tauri star and Herbig Ae star for the former and the latter issues, respectively. The results of the chemical models with and without the carbon grain destruction show significant differences especially near the midplane in the inner disk, where CO gas is abundant and not photodissociated. Carbon bearing species, e.g., HCN, become abundant while oxygen bearing species, e.g., H_2O, becomes less abundant in the model with carbon grain destruction inside 2 au near the midplane in the T Tauri disk. Meanwhile, we calculate the solid carbon fraction relative to the total elemental abundance of carbon as a function of radius in the inner disk. In the model without carbon grain destruction, the ratio is about 75 % and doesn't change very much at different radii since the majority of the carbon is locked in the refractory form. In the model with carbon grain destruction, the solid carbon fraction decreases in the inner disk as icy carbon-bearing species evaporate into gas inside their snowlines. However, in order to match the gradient in the solid carbon fraction in our solar system quantitatively, we will need a more comprehensive model.

Solid carbon fraction relative to the solar abundance of carbon		
	w/o destruction	w/ destruction
10 au	75.254 %	43.592 %
5 au	75.254 %	40.841 %
4 au	75.659 %	40.769 %
3 au	75.670 %	40.735 %
2 au	75.295 %	39.945 %
1 au	75.254 %	1.0(-5) %

Furthermore, we consider HCN and its isotopologue, $H^{13}CN$ and c-C_3H_2, as our candidate tracer of the carbon grain destruction, and make a prediction for the ALMA observations.

We summarized this work and submitted it to ApJ October 2018.