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Orbital Evolution of Centaurs and their activity

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We have investigated the orbital evolution of Centaurs and their cometary activity.

According to the orbital integrations by many authors, Centaurs are thought to be objects that are transitioning between the Kuiper Belt region and the inner solar system. Due to the strong perturbations from giant planets, Centaurs have short dynamical lifetime of ~10^7 years: about two-thirds are ejected from the solar system and one third are injected into the inner region to be called Jupiter family comets (e.g., Volk&Malhotra 2008.) According to Jewitt (2009), 16 active Centaurs have been found. It is curious that some of such Centaurs show cometary activity. Their activity cannot be explained as an ordinal water sublimation of short-period comets since they are too cold for water sublimation to be effective and also too hot to keep CO ice. The alternative mechanism of their activity has been proposed and discussed in Jewitt (2009). Jewitt said that if Centaurs contain the amorphous ice that is porous and have enough space to keep CO gas, the CO outgassing occurs when the amorphous ice transforms into crystalline form. Observations of Centaurs support the hypotheses that the crystallization of amorphous ice (thermal process) is the trigger or driver of activity. But we have no idea how long the activity maintained. Guilbert (2012) calculated the 3-D thermal evolution of icy body due to the heat from the Sun in detail, including the seasonal variation. She found that the crystallization of amorphous ice is completed in 10^4-5 years. However, Guilbert assumes circular orbits despite that the chaotic orbits and the short dynamical lifetime of Centaurs.

Now we try to combine the orbital evolution and thermal evolution. We calculate the orbital evolution of Centaurs and the crystalline fraction as functions of time. To calculate the crystalline fraction, we use equation (26) in Kouchi et.al. (1994) that gives the crystalline fraction of water ice under the temperature which varies with time. We calculate the temperature as a function of the heliocentric distance. We found that the crystallization timescale is much shorter than that of the propagation of the heat wave from the moment the object reaches a new surface thermal balance in the giant planets region, 10^4-5 years, derived by Guilbert (2012). We also found that the orbital distribution obtained from observations is roughly well reproduced assuming Guilbert's timescale and our orbital integration. In the presentation, we will estimate and discuss the fraction of new Centaurs by comparing our results and the observations.

Keywords: Centaurs, orbital evolution, amorphous ice, cometary activity