平成 21 年度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

研究課題名

Dynamics of Near-Earth Objects (地球接近小天体の軌道進化)

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利用カテゴリ　汎用 PC

I would like to summarize my activities in terms of CfCA. I have been contributing to the Pan-STARRS project collaborating mainly with Institute for Astronomy (IfA), University of Hawaii. The Panoramic Survey Telescope And Rapid Response System "Pan-STARRS" is a project, initiated by the University of Hawaii, to repeatedly survey covering three quarters of the entire sky to discover a very large number of new asteroids and comets. The operations for the first Pan-STARRS telescope (PS1) are funded by a consortium including National Central University (NCU), Taiwan. Solar system moving objects such as asteroids and comets are crucial targets for the Pan-STARRS project and a grate contribution is made by the Institute of Astronomy, National Central University.

My research work on the Near Earth Asteroids (NEAs) collaborating with Pan-STARRS colleague made a significant progress which is about to submit to Nature (2010) entitled "The extremely recent breakup of a fragile near-Earth asteroid", Shinsuke Abe(NCU), Mikael Granvik(IfA), Robert Jedicke(IfA), Richard Wainscoat(IfA), David Tholen(IfA), Larry Denneau(IfA), Tommy Grav(JHU), Daisuke Kinoshita(NCU), Chan-Kao Chang(NCU), Wen-Ping Chen(NCU) & Wing-Huen Ip(NCU).

It is widely accepted that asteroid families are formed in the main belt region between Mars and Jupiter through the catastrophic disruption of a large parent body followed by chaotic dynamical orbit evolution of the fragments. We have identified the first genetically related pair of Near Earth Asteroids through the extreme similarity of their orbits. Multi-colour photometry of both objects was obtained with the Gemini 8.1-m telescope on January 3-4 and their colours match those of B- and F-type asteroids that, surprisingly, comprise only 5% of the NEA population. The similarity of their orbits and colours leads us to believe that they are fragments (0.92 km and 0.24 km respectively) from the disruption of a larger parent object. It is likely that tidal forces during close encounters with Mars around 110,0000 years ago caused the fragmentation of the parent asteroid making this the youngest known asteroid family. The discovery of this genetically related NEA pair suggests that there are likely to be more fragmented asteroids on Earth-orbit crossing trajectories. Considering the rarity of the B- and F-type asteroids and the existence of a dynamical pathway between the orbits of this NEA pair and (3200) Phaethon (a parent body of Geminid meteor shower), it is suspicious that this NEA pair, the Earth impacting asteroid 2008 TC3 and the Phaethon-Geminid meteor stream complex are all of F-type - perhaps these types of asteroids are particularly weak and easily disrupted. The existence of tidally disrupted asteroid "streams" in the NEA population would have implications for the rate of Earth impacts.

Our discovery is of great importance to know the breakup asteroid family by the planetary tidal force and the connection between comets and asteroids in the inner solar system. Our innovative approaches with a wide field of vision in terms of a new dissimilar formula which identifies the breakup NEA pair and observational evidences that ensure spectral (composition) similarities generates new insights for asteroids and comets in the solar system. Our discovery of the first NEA family and its probable formation in a tidal disruption event provides interesting opportunities for testing disruption models that can predict the number of fragments, their size distribution and rotation rates. As next-generation sky surveys (e.g., Pan-STARRS, Subaru-HSC) begin to image the sky the discovery rate of NEA families will certainly increase and provide ever more opportunities to test these and similar models of the formation of asteroid families.

Besides above mentioned NEA pair, I'm also working on dynamical evolution of several near-Earth objects, collaborating with Dr. Ohtsuka and Prof. Ito. Especially Prof. Ito helped the improvement of my computation efficiency using CfCA. We are going to continue and finish our work in 2010. Finally, I would thank all effort to maintain the CfCA facility.

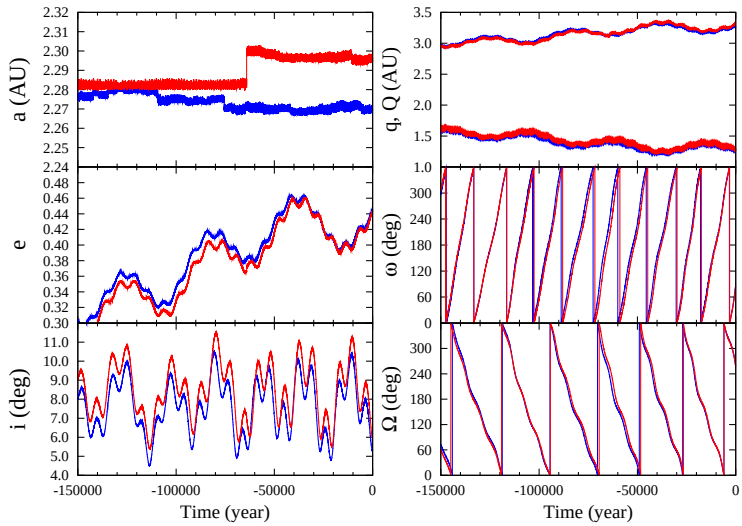

図 1: The backward time evolution of orbital elements for the discovered near-Earth asteroid pair starting on Jan 4, 2010. In order to search the breakup time, orbital evolution of 2,000 clones for each objects was computed over 20 ky. Data analyses were in part carried out on the general-purpose PC farm at the Center for Computational Astrophysics, CfCA, of the National Astronomical Observatory of Japan.

参考文献

[1] **Shinsuke Abe**, Robert Jedicke, Richard Wainscoat, David Tholen, Larry Denneau, Tommy Grav, Daisuke Kinoshita, Chan-Kao Chang, Wen-Ping Chen, and Wing-Huen Ip, *The extremely recent breakup of a fragile near-Earth asteroid*, submitted to Nature (2010), 査読付き欧文論文.