Are slow earthquakes spatio-temporal chaos?-Reproducing slow earthquakes as the Benjamin-Feir instability

*住野 豊[1]、齋藤 拓也[2]、波多野 恭弘[2]、山口 哲生[3]
*Yutaka Sumino[1], Saito Takuya[2], Takahiro Hatano[2], Tetsuo Yamaguchi[3]

1. 東京理科大学、2. 東京大学、3. 九州大学
1. Tokyo University of Science, 2. The University of Tokyo, 3. Kyushu University

A slow earthquake [1] is a type of shear slip observed at plate boundaries similar to regular earthquakes. However, slow earthquakes show different scaling from regular earthquakes, not only their characteristically long durations [2]. It is also known that their cumulative number of observation is an exponential function of the released energy [3]. This shows distinctive contrast with regular earthquakes that have Gutenberg-Richter law. Since slow earthquakes release the energy stored, simple description of their dynamics will be helpful to predict the spatio-temporal dynamics of the stress distribution along subduction zones.
In order to understand physical aspects of slow earthquakes, we analyze the rate and state friction model [4]. The rate and state friction model is a widely used mathematical model for a rock friction, which was introduced by Dietrich. Interestingly, it is known to reproduce slow earthquake near the instability threshold. To understand underlying mechanisms, we first derive a simplified expression of the rate and state model near Hopf bifurcation point. This simplified expression can be used to adopt spatial dimension as well.
We, as a first step, incorporate the rate and state friction model into a thin 1-dimensional elastic layer, which has local coupling [5]. We simplify the thin 1-dimensional elastic layer with the rate and state friction into the complex Ginzburg Landau equation. We confirm that this simplified equation shows the Benjamin-Feir instability at an appropriate condition, leading to spatio-temporal chaos. We further discuss some characteristic features of slow earthquakes from the view point of such spatio-temporal chaos.

[Reference]
[1] K. Obara, Science 296 1679 (2002).
[2] S. Ide et al., Nature **447** 76 (2007).
[3] S. Yabe and S. Ide, *J. Geophys. Res. Solid Earth* **119** 8171 (2014).
[4] J. H. Dietrich, *J. Geophys. Res.* **84**, 2161 (1979), J. R. Rice, A. L. Ruina, *J. Appl. Mech.* **50** 343 (1983).
[5] J. M. Carlson and J. S. Langer, *Phys. Rev. Lett.* **62** 2632 (1989), H. Kawamura, et al., *Rev. Mod. Phys.* **83**, 839 (2012).

キーワード：rate and state friction、Benjamin-Feir不安定性、複素ギンツブルグランダウ方程式
Keywords: rate and state friction, Benjamin-Feir instability, complex Ginzburg Landau equation

