HOMOCLINIC BIFURCATION DRIVING CHEMICALLY ACTIVE CREEPING FAULTS

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This talk addresses the mathematical basis for the emerging topic of applying multi-physics frameworks to understand and study the governing mechanisms of complex phenomena at a geophysical scale. As suggested in Poulet et al. (2014a, b), a fundamental analysis of multiple steady-states, originally developed for combustion physics, can be used in fault mechanics to describe the temporal evolution of subduction zones and the spatial manifestation of exhumed thrusts (Alevizos et al. 2014). The main feature of this model is the coupling of a shear heating mechanism due to the material's internal friction, to an endothermic chemical reaction triggered by the temperature increase caused by prolonged shearing. In this study, we recapitulate the model's main features and use the arc-length continuation method proposed by Chan & Keller (1991) along with Spectral Element Method to produce bifurcation diagrams of its equilibrium solutions (Fig. 1). Furthermore, due to the appearance of complex eigenvalues in the upper branch of the solutions, we integrate the time-dependent system numerically in an effort to prove the existence of limit cycles. This leads to the discovery of a homoclinic bifurcation which defines the system's global behavior, since it self-organises around the homoclinic point B (Fig. 1).

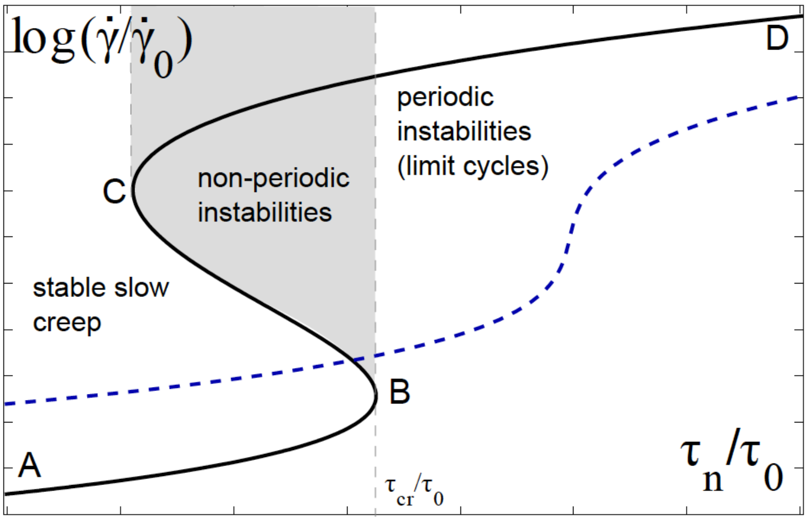

Figure 1. Bifurcation diagram of the model proposed by Alevizos et al. (2014). The system exhibits a folded S-curve response (solid black curve) or a stretched one (dashed blue curve) depending on the normal stress at the fault's boundary. As depicted by the highlighted areas of the diagram, depending on the normalized shear stress at the boundary (τ_n/τ_0), the system exhibits stable creep, periodic and non-periodic instabilities. The point B in this diagram is a homoclinic point.

References

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