Current general understanding of basic *earthquake physics*

Crustal earthquakes nucleate as frictional instabilities on preexisting faults and propagate as dynamic ruptures (or cracks).

Much more detailed understanding is needed to:

find possible scenarios for large earthquakes,
predict strong ground motion,
assess seismic hazard.

Some of existing fundamental questions

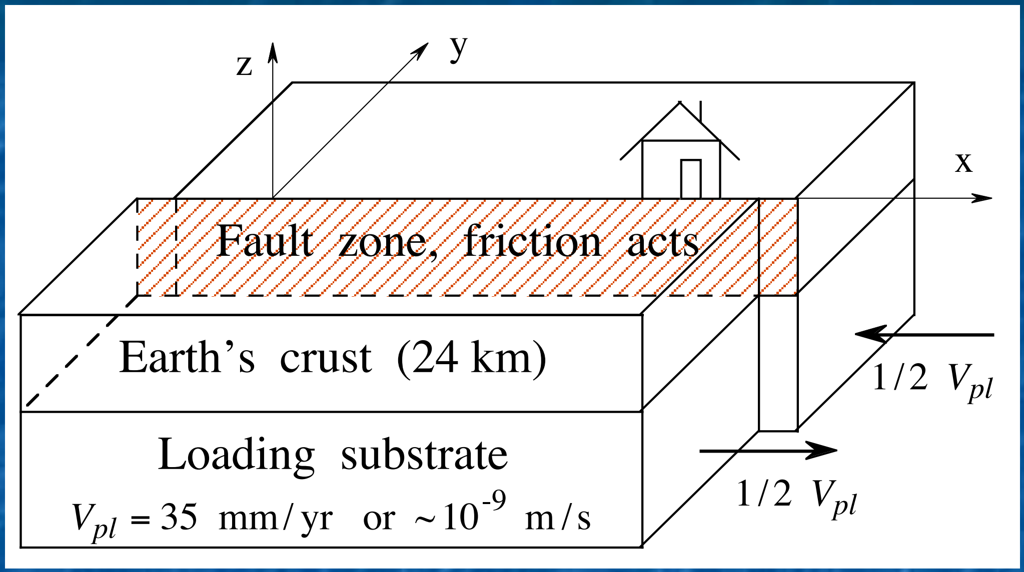
How do earthquakes nucleate and arrest?

Can we distinguish between the beginning of large and small events?

What are the appropriate description and parameters of fault friction?

How do heterogeneities in fault properties affect rupture propagation?

Model of a vertical strike-slip fault



Complicated nonlinear system of equations:
Equations of elastodynamics in the bulk for displacements;
Nonlinear time-dependent boundary conditions on the fault (friction).

We need to solve for how the earthquakes will occur un detail:
Given a certain loading and frictional properties of the fault,
determine how the relative displacement on the fault will accumulate.

To answer those questions, we need *efficient computational methods* that can deal with this *challenging* problem

Multiple scales in space

Fault dimensions	100 km = 10^5 meters
Distance for rapid changes of variables at the rupture tip	fraction of a meter
Heterogeneous properties of the fault, on various scales	

Multiple scales in time

Duration of crack propagation	10-100 seconds
Time for rapid changes of variables at the rupture tip	fraction of a second

Earthquake is a dramatic failure event:

The tip of the rupture spreads with speeds close to the shear wave speed of the material, about 3 km/sec for rocks.

The particle velocities (how fast points are moving past each other) are 1 m/sec on average.

Question for the project

Can one apply coarse-fine integration methods developed

In the CDS community to study earthquake phenomena?

In coarse-fine integration methods (i.e., Kevrekidis et al., 2004), there are two levels of problem description:

the actual, or “fine”, simulation (time-consuming, with lots of degrees of freedom) and

the “coarse” description (updates in no time, involves several dynamic variables that adequately describe the large-scale behavior of the system).

The “fine” simulation called upon only occasionally, for short periods of time, to determine the evolution of the “coarse” variables.