Quakes: from the Earth to Stars
May 20-23, 2023, Dream Field near FAST, Guizhou, China

Structure and stress interaction between planetary interior layers: A case study on Tibet Plateau

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Abstract: Planetary interior layers are believed to be coupled. Stress perturbations in one layer may cause prolonged time-dependent stress relaxation in neighboring layers. The surface deformation in response to the interior stress perturbation (such as earthquakes) may be recorded at geodetic stations and thus help to constrain the rheological structure and properties of interior layers. We took a case study on Tibet Plateau. We studied the postseismic deformation of the 2015 Mw7.8 Nepal, 2008 Mw7.9 Wenchuan and 2001 Mw7.9 Kunlun earthquakes from the deformation front to the Tibetan interior to constrain the rheological properties of the lithosphere and upper mantle as well as the stress interaction between the rheological units. We have developed a three-dimensional viscoelastic finite element model that includes an elastic upper plate and subduction slab, a viscoelastic mantle wedge, oceanic asthenosphere and upper mantle. Afterslip of the fault is simulated by a 2-km weak shear zone attached to the fault. Viscoelastic relaxation of the earthquake-induced stresses is represented by the biviscous Burgers rheology. Following previous studies, we assume that the transient Kelvin viscosity is one order of magnitude lower than that of the steady Maxwell viscosity. On the basis of the comparison of observed postseismic deformation at GPS stations, test models have determined the steady-state viscosity of the lower crust to be from 3×10^{18} Pa s at the deformation front to 2×10^{19} Pa s at the northern edge of the Tibet Plateau and up to 10^{20} Pa s at the Qaidam basin. The test model successfully reproduces the first-order pattern of the GPS observations both in the horizontal and vertical directions. Model results indicate that the afterslip of the fault takes place mostly in the vicinities of the rupture zone and decays rapidly with time. Test models of the 2008 Wenchuan earthquake indicate that aftershocks occur mostly in areas with postseismic stress perturbation of no less than 100 kPa. The

Wenchuan earthquake causes more than 20 kPa stress change within ten years after the earthquake in neighboring crustal faults, and thus may increase seismic potential at portions of the active faults.

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Quakes of compact stars

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Abstract: Pulsar quakes have the potential to trigger a range of phenomena, including glitches caused by changes in inertia. These quakes can be triggered by the build-up of stress resulting from a star's spin-down. In this work we discussed spin-down's stress loading, types of starquakes, and co-seismic change of inertia moment by a quake. We calculated the stress distribution to determine the optimal type of starquakes at various locations. Then we estimate the quake's scale on pulsars and the glitch amplitude that a quake will cause. The work is on a neutron star model and a strangeon star model. The two models gives notable differences. With a much larger scale than quakes on Earth, the quake on strangeon stars can explain the observation of the amplitude of glitches.

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Repeating fast radio burst: Starquake-induced coherent radiation

Weiyang Wang

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Abstract: I will give an introduction of fast radio burst in these 15 years. I propose to understand the polarization characters via coherent curvature radiation from a bulk of charged bunches in the magnetosphere of a highly magnetized neutron star. The bursts are triggered by neutron starquake and some burst sequences can exhibit Earthquake-like behaviors.

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Elastic properties of neutron star matter and crustal torsional oscillations

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Abstract: Realistic estimations on the elastic properties of neutron star matter are carried out with a large strain ($\varepsilon \lesssim 0.5$) in the framework of relativistic-mean-field model with Thomas-Fermi approximation, where various crystalline configurations are considered in a fully three-dimensional geometry with reflection symmetry. Our calculation confirms the validity of assuming Coulomb crystals for the droplet phase above neutron drip density, which nonetheless does not work at large densities since the elastic constants are found to be decreasing after reaching their peaks. Similarly, the analytic formulae derived in the incompressible liquid-drop model gives excellent description for the rod phase at small densities, which overestimates the elastic constants at larger densities. For slabs, due to the negligence on the variations of their thicknesses, the analytic formulae from liquid-drop model agree qualitatively but not quantitatively with our numerical estimations. By fitting to the numerical results, these analytic formulae are improved by introducing dampening factors. The impacts of nuclear symmetry energy are examined adopting two parameter sets, corresponding to the slope of symmetry energy $L = 41.34$ and 89.39 MeV. Even with the uncertainties caused by the anisotropy in polycrystallines, the elastic properties of neutron star matter obtained with $L = 41.34$ and 89.39 MeV are distinctively different, results in detectable differences in various neutron star activities. We then investigate the corresponding crustal torsional oscillations and compare them with the observed quasiperiodic oscillations in magnetars.

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Pulsar Timing and Glitch

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Abstract: Pulsars are highly magnetized, rotating compact objects, and are generally observed to pulse regularly from the radio band to high energy X-ray and gamma-ray band. Due to this stability of the spin, the pulse times of arrival (TOAs) could be predicted with high precision. The rotating models of pulsar could be constructed accurately by fitting the TOAs, and this technique is called pulsar timing. A glitch is an abrupt increase in the spin frequency of a pulsar, which is often followed by a recovery process. And starquake model was proposed to explain the pulsar glitches, as well as other models. With pulsar timing technique, this process can be measured, and the theoretical models of pulsar glitches could be tested. I will generally introduce pulsar timing technique, and discuss pulsars glitches.

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From Quark to Quake

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Abstract: Human beings are civilized by understanding the nature of our material world, the basic unit of which are atoms and molecules bound by the electromagnetic interaction. All of the natural phenomena could then be explained, including typhoon and earthquake, the latter is relevant to elastic loading and release in solid bodies. Similar to normal atom matter dominated by electric force, nucleon matter and strangeon matter are condensed by the fundamental strong interaction, and quakes could also occur on the latter if in a solid state. Observational consequences of strangeon star quake would be discussed in the presentation.

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Does Stress Drop Positively or Negatively Correlate With Rupture Speed?

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Abstract: Rupture speed V_r and stress drop $\Delta\tau$ are two key parameters that can characterize earthquake source and the associated potential for ground shaking. Despite their importance, a controversy has emerged in recent years regarding whether there is a positive or negative correlation between $\Delta\tau$ and V_r. Here I attempt to reconcile the controversy by presenting a context-based solution and a physics-based solution. The first solution calls for attention to the specific context under which V_r and $\Delta\tau$ are discussed, as their meanings and estimated values can vary between different studies. It is noted that a negative correlation between $\Delta\tau$ and V_r can result, at least partly, from a tradeoff effect inherent to certain analysis method. For the second solution, it is shown that the specific correlation between $\Delta\tau$ and V_r can depend on the condition of fracture energy G_c. Constant G_c often favors a positive correlation, whereas introducing a variability of G_c can lead to a negative correlation. More efforts are needed to improve the methods for estimating V_r and $\Delta\tau$, and to explore other mechanisms that may explain the correlation between the two parameters.

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Small glitches and anti-glitches from non-axisymmetric oscillation modes

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Abstract: In this talk, I will outline a novel model that can explain small glitches and anti-glitches. In brief, the model posits that the excitation and decay of a non-axisymmetric f-mode can result in a neutron star suddenly spinning up or down, depending on whether a retrograde (against rotation) or prograde (with rotation) mode is excited. A consequence of this is that a burst of gravitational waves will be emitted each time one of these modes it excited, allowing the model to be independently testable. We will comment on the detectability of these modes with gravitational wave detectors. Finally, we will assess how much energy is required to power these modes and whether this could come from elasticity during the spin down between spin-up or spin-down events.