Field Guide to Neutron Star Mountains

Sierra Club (Not LVC) -170817

Rock Types

- Accreted crust
- Equilibrium crust
- Magnetic
- Solid quark matter (some field reports, unconfirmed)

How can nuclear physicists help?

- Knowledge of EOS, NS radius, for example NICER, moment of inertia, crust properties (for example crust thickness from crust cooling observations) will improve.

- Sheer modulus, perhaps breaking strain, of pasta from MD, DFT … simulations

- Stressing realistic (?) models of nonuniform crusts

- Better models / calculations of quark matter including solid phases.

The Accreted Mountains

- May provide torque balance either continually or time averaged.

- Size: ellipticity ~ few 10^{-8}

- Formation mechanisms: thermal gradient and electron capture layers, crust breaking …

- Search issues: unknown spins, binary orbit, torque wandering…

- **Benchmark:** probe torque balance for optimal frequency and then for an increasing range of frequencies.

The Young Mountains

- Size: so far only large >= Crab few 10^{-5}.
- Rock types: so far only solid quark matter.
- Formation mechanisms: something very energetic and very early in life of protoneutron star…
- Question: Why don't young NS spin faster?
- Search issues: less sensitive at low frequencies.
- **Benchmark**: beat "crust limit" $\epsilon=10^{-5}$ for Crab. Then sensitive to maximumly deformed crust.

The “Recycled” Mountains

- On recycled millisecond pulsars
- Size: small ~ few x 10^{-9}
- Formation mechanism: residual accreted mountains, or minimal deformations
- Question: Do MSP spin down limits cluster and end near $\epsilon=10^{-9}$?
- Search issues: low amplitude, lower high frequency sensitivity, known spins, clean systems, …
- **Benchmark**: beat spin down limit for millisecond pulsar.

The Unknown Mountains

- Large, loud and wonderful!