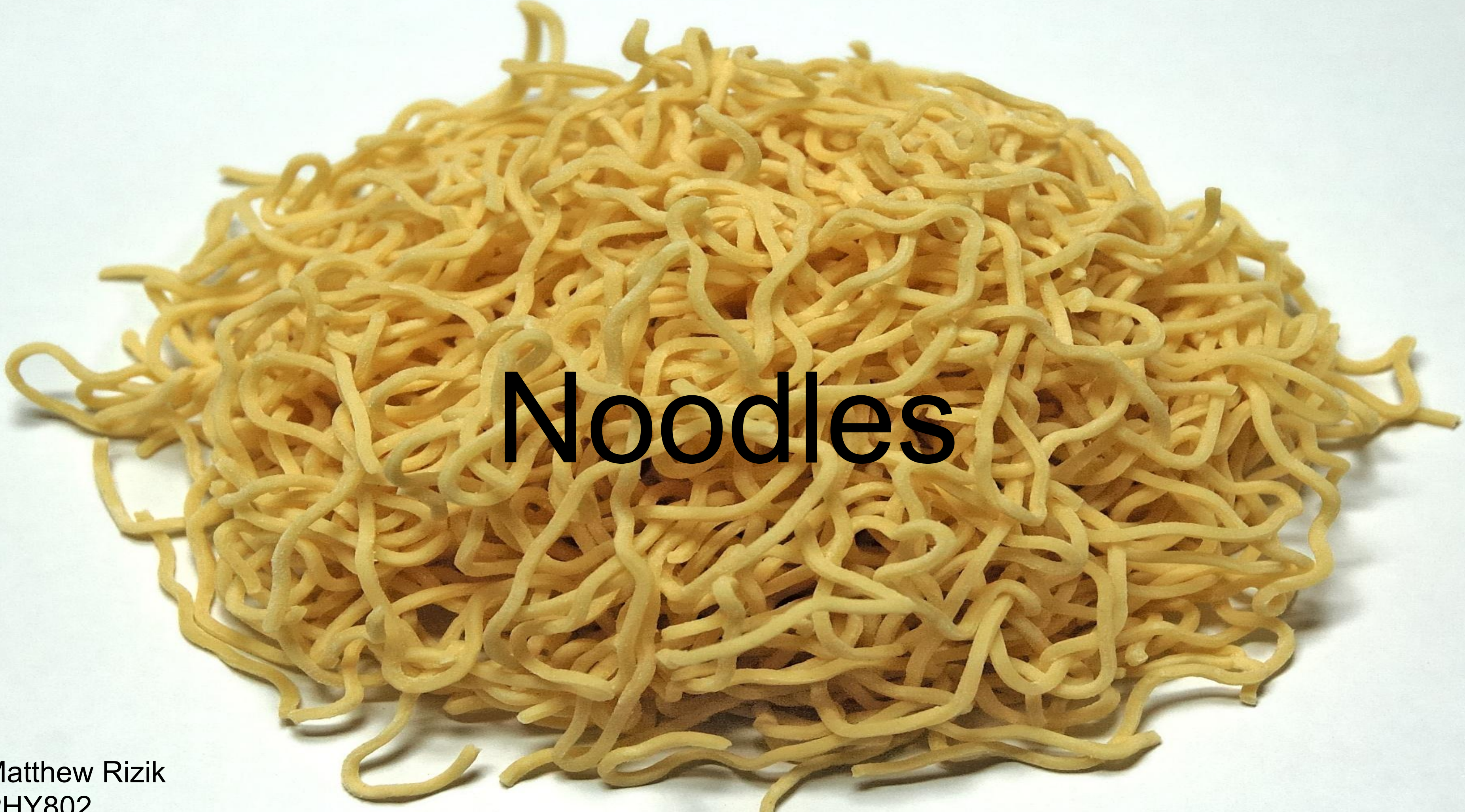
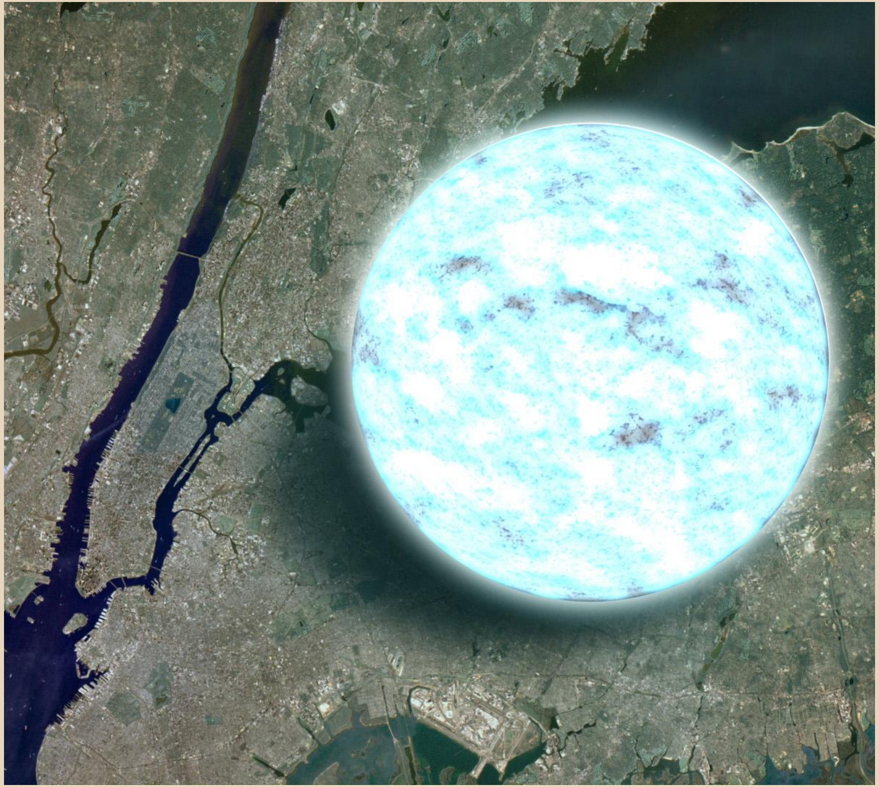


Noodles

Matthew Rizik
PHY802

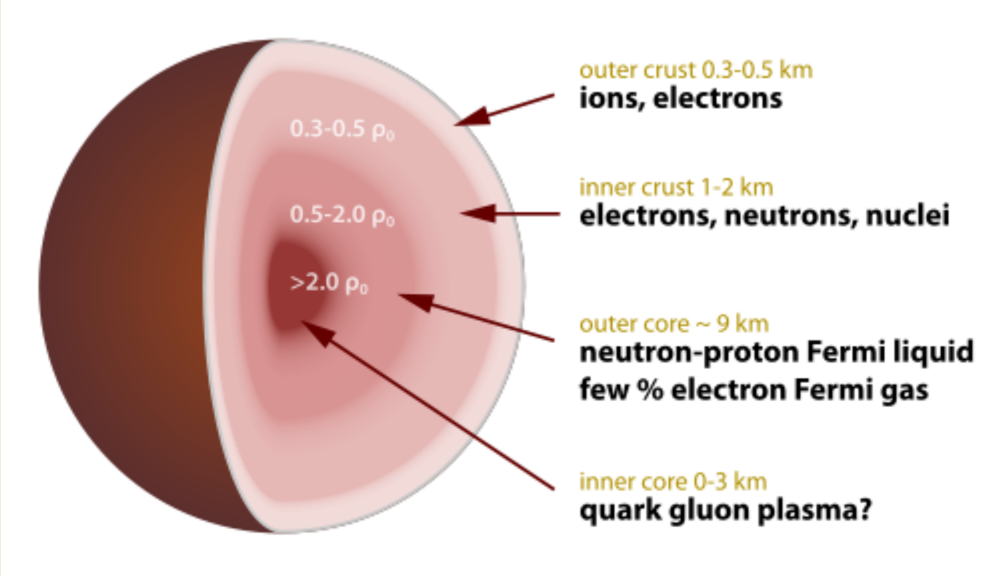
Neutron Stars

- Stellar remnants with masses between 1.44 and 3 solar masses
- smallest, densest stars known
- When a main sequence star begins to reaches iron fusion, gravitational pressure dominates.
- Star collapses with sufficient mass to overcome degeneracy pressure of electrons, heating the star to five billion K.
- Gamma rays break iron nuclei into alpha particles.
- Electrons gain enough energy to emit W-bosons, transmuting protons to neutrons.
- Neutron degeneracy pressure balances gravity

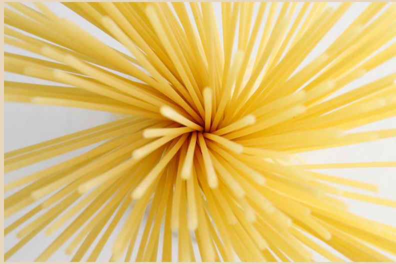


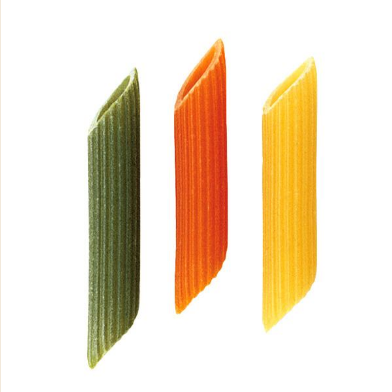
Origins

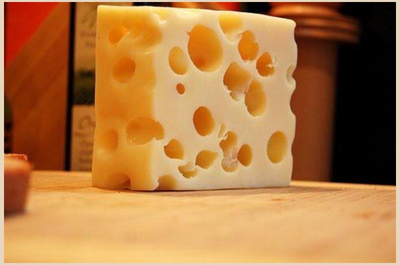
- Between the QGP (??) core and the surface
- At ~10^{14} g/cc, the strength of QED and QCD interactions are of similar magnitude.
- Novel setting generates unique emergent phenomena. Requires protons!



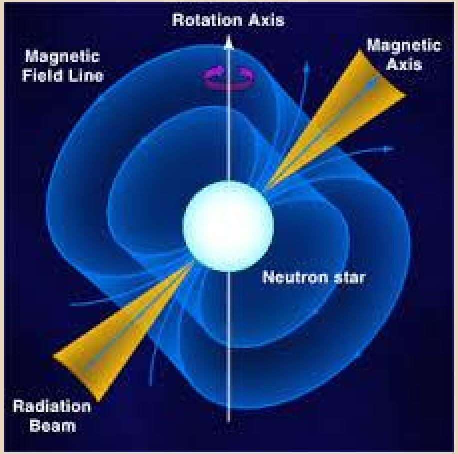
Transitions and Formation



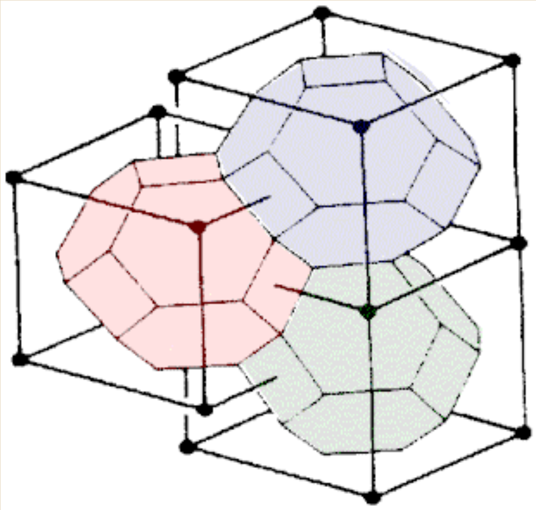




Solid State Properties



- Spin periods of isolated X-ray pulsars seem to have an upper bound at ~12s
- Traditional estimates should allow periods to reach 20s-30s in ~100,000 years.
- Magnetic field dissipation contributes to the change in period.
- Dissipation governed by transport properties within the star
- Location and size of currents crucial
- Crust currents ⇒ quick decay
- Core currents ⇒ slow decay (large σ)



Solid State Properties

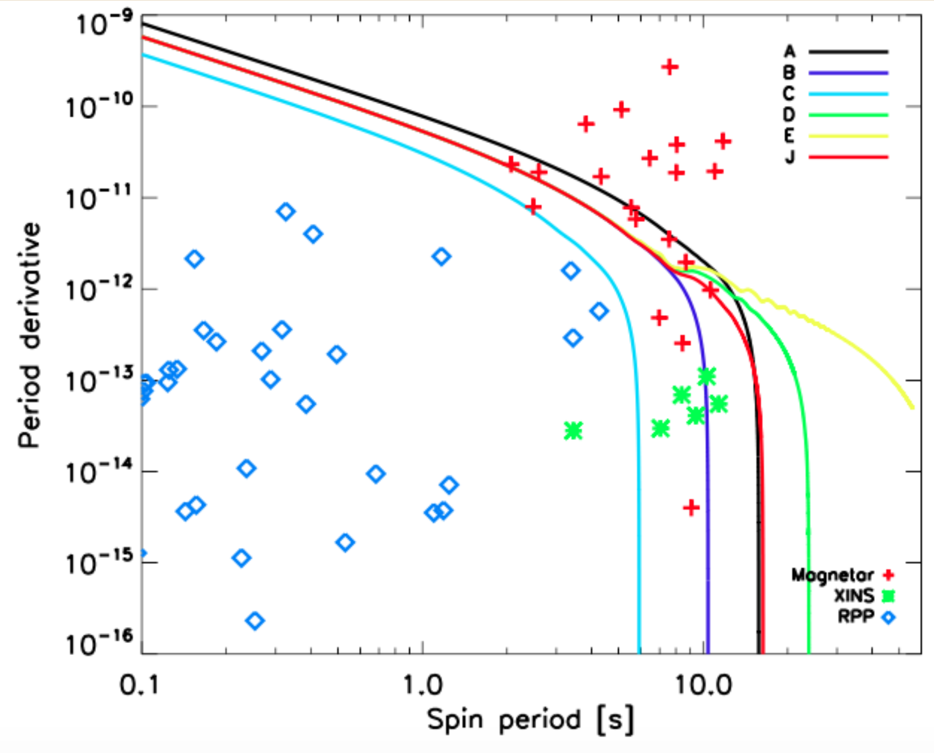
- Q_{imp} “impurity parameter”
  - $Q_{imp} >> 1$, amorphous
  - $Q_{imp} << 1$, crystalline
- Pasta is manifestly disordered ⇒ large Q_{imp}
- Deviations from perfect lattice structures decrease conductivity.
- MD, QMD simulations predict appreciably lower values than Q_{imp} formalism.
- Energy loss:

$$\dot{E} = \frac{B^2 R^6 \omega^4}{4c^3}(1 + sin^2\theta)$$

- Low *B*, low period (and conversely)
- P-P’ evolution can be numerically calculated
- Can be compared to observation

Conclusions

- Highly irregular crusts bend the P-P’ curve down
    - There will be a maximum spin period for X-ray pulsars
- T-dependent properties may be more or less neglected (e^--imp scattering)
- Pasta provides this framework
- Competing theory: totally amorphous interior
- Refined theory needed



Acknowledgements

Pons, Jose A., Daniele Viganò, and Nanda Rea. "A Highly Resistive Layer within the Crust of X-ray Pulsars Limits Their Spin Periods." *ArXiv*. N.p., 24 Apr. 2013. Web.

Schneider, A. S., C. J. Horowitz, J. Hughto, and D.K. Berry. "Nuclear Pasta Formation." *ArXiv*. N.p., 5 July 2013. Web.

Spitkovsky, Anatoly. "TIME-DEPENDENT FORCE-FREE PULSAR MAGNETOSPHERES: AXISYMMETRIC AND OBLIQUE ROTATORS." *SLAC* (n.d.): n. pag. 7 Mar. 2006. Web.


Fin