Fundamental Objectives:
- Determination of the EoS of dense matter.
- What is composition of dense matter, and its thermodynamic and transport properties?
- What is the maximum density and the maximum pressure?
Key achievements

- **Astrophysical Observations:**
  - Two solar mass neutron star (pulsar): J1614-2230 has important implications about the EoS and the role of quark matter in the core.
  - X-ray bursters: mass-radius relations - EoS, crustal conductivity
  - Magnetars: crustal vibrations – EoS, shear viscosity:
- **Laboratory Measurements:**
  - Exploitation of giant and pygmy resonances, heavy ion collisions, mass, isobaric analog resonances, skin thicknesses to constrain EoS.
- **Theory:**
  - Establishing connections: neutron star observables <= EoS.
  - Establishing connections: laboratory observables <= EoS.
  - Ab-initio calculations of EoS from realistic interactions.
Towards the EoS: illustrative examples:

\[ S(\rho) = S_0 + \frac{L}{3} \left( \frac{\rho - \rho_0}{\rho_0} \right) + \frac{K_{\text{sym}}}{18} \left( \frac{\rho - \rho_0}{\rho_0} \right)^2 + \ldots \]

\[ E/A (\rho, \delta) = E/A (\rho, 0) + S(\rho) \cdot (\rho_n - \rho_p)^2 / \rho^2 \]

- At \( \rho < \rho_0 \), laboratory observables and neutron star observables provide some constraints on the symmetry energy.
- Precision will improve.

- At \( \rho > \rho_0 \), some initial constraints are also available.
- However, laboratory constraints on the symmetry energy at \( \rho > \rho_0 \) are not yet available.
Opportunities and needs

• Astrophysics:
  – Concerns: IXO cancelled. Funding for GBT (where 2 solar mass N-star was observed) is threatened. A strong statement affirming the importance of EoS work is warranted and could be important.
  – New opportunities: LOFT (Large X-ray timing satellite:2022 ); Development of smaller Explorer class instruments.
  – Continued availability of Chandra and XMM-Newton.

• Laboratory Measurements:
  – Key issue is development of facilities (FRIB) to produce intense beams of rare isotopes for laboratory investigations of neutron–rich nuclei and nuclear matter.
  – There are excellent opportunities to improve present constraints at $\rho<\rho_0$ and extend them to higher densities $\rho\approx2\rho_0$.

• Theory is essential to these efforts:
  – Theoretical support and development is essential to refine connections between measurement and the EoS and assist in the development of new directions. This requires concerted efforts.