Modeling Differentially Rotating Strange Quark Stars

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Outline

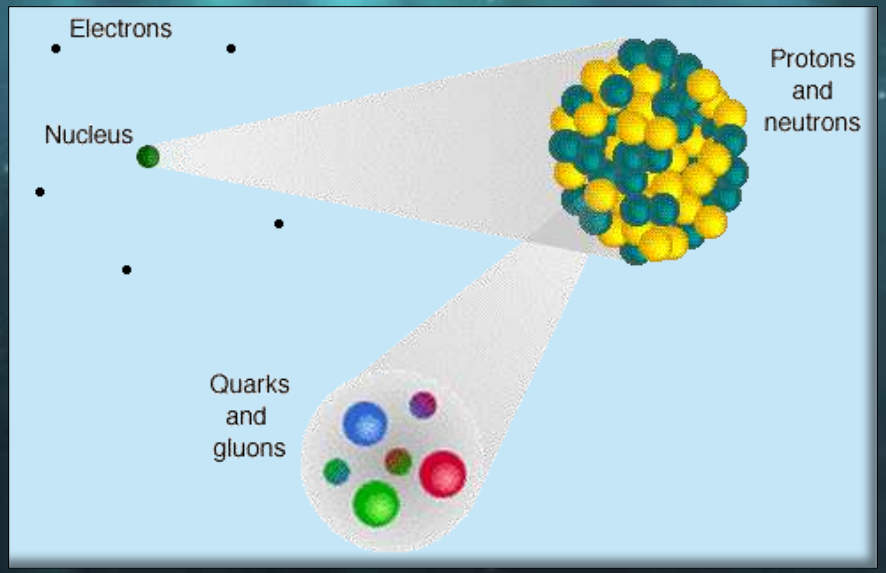
- Quarks
  - What are Quarks?
  - Quark Star Theory
- Conservation Equations
  - Momentum Equation
- Self-Consistent Field Method
- Future Refinement
- Observational Data
- Application
- Acknowledgements

What is a quark?

- A quark is one of the basic constituents of matter.

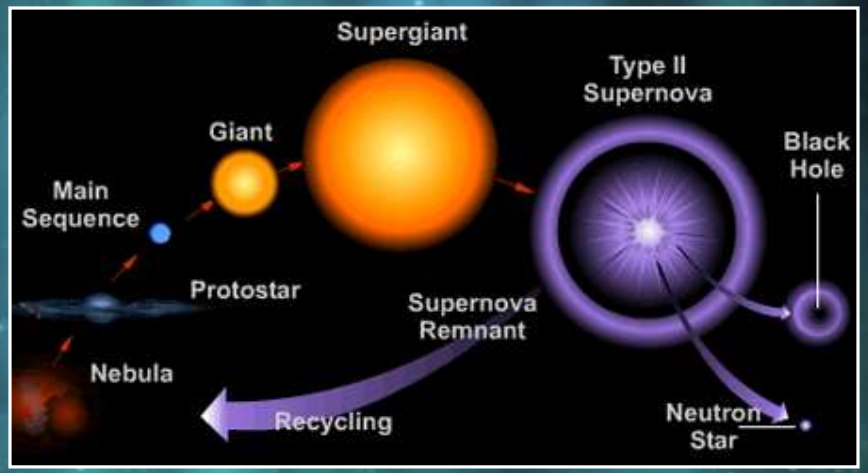
Types of quarks:

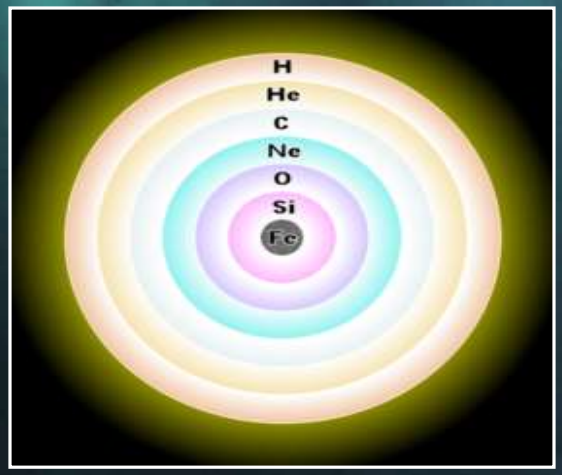
Quarks can be combined to form elementary particles.

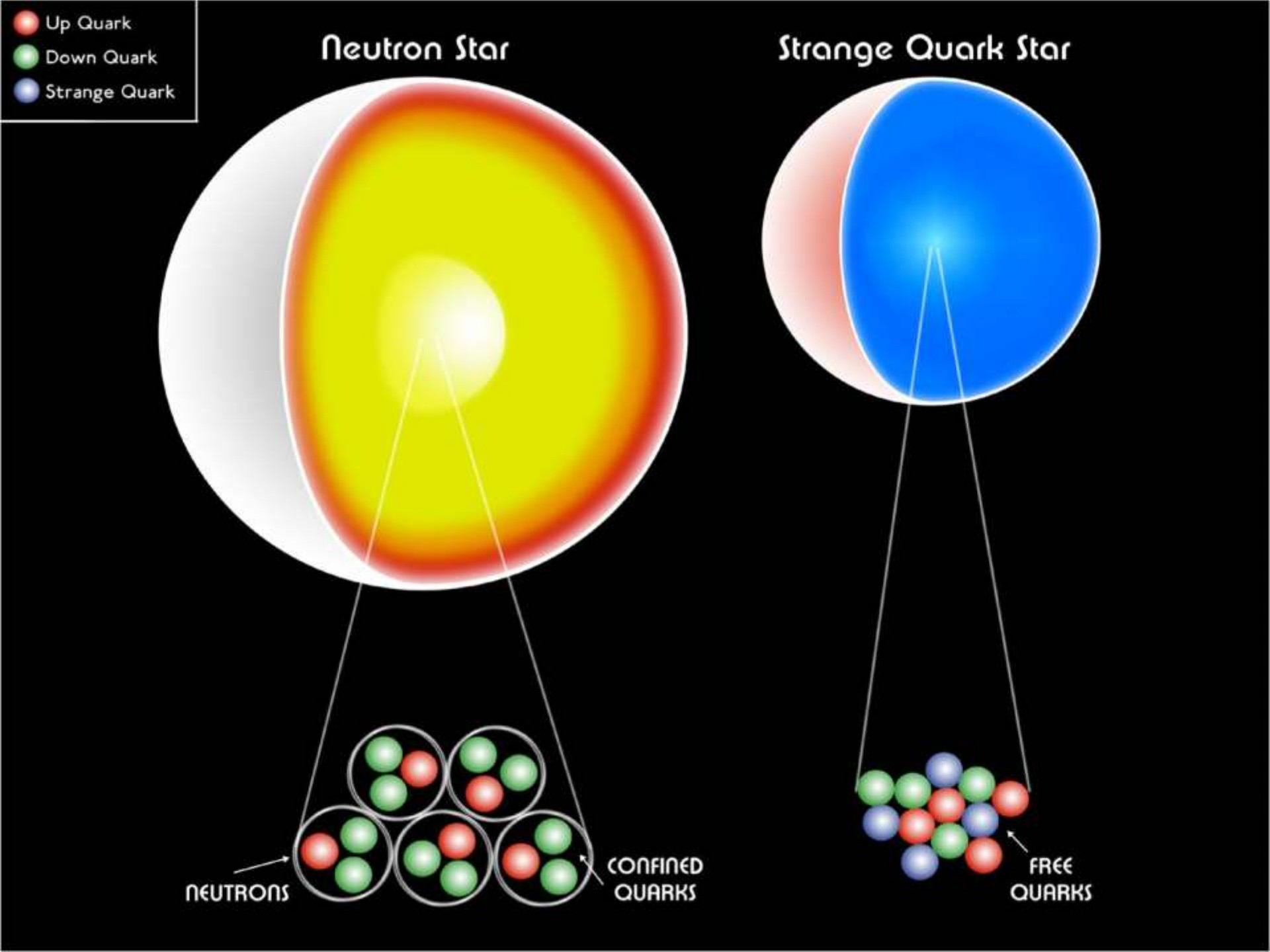


Quark Star Theory

- Supernova:
  - Aging massive stars fuse heavy elements to halt collapse.
  - Photodissociation and collapse.
  - Core crushed Into Neutron star, Quark star or Black hole.
- Neutron Star:
  - Very dense.
  - Supported by neutron degeneracy pressure.
- Quark Star:
  - Deconfined quarks.
  - More dense than Neutron Star.
  - Supported by quark degeneracy pressure.






Up Quark
Down Quark
Strange Quark
Neutron Star
Strange Quark Star
NEUTRONS
CONFINED QUARKS
FREE QUARKS

Conservation Equations

Momentum Conservation

$$\rho\left(\partial_t + \vec{v}\cdot\vec{\nabla}\right)\vec{v} = -\vec{\nabla}P - \rho\vec{\nabla}\Phi_g$$

Energy Conservation

$$\left(\partial_t + \vec{v}\cdot\vec{\nabla}\right)P\rho^{-\gamma} = (\gamma - 1)(\Gamma - \Lambda)$$

Continuity Equation

$$\partial_t\rho + \vec{\nabla}\cdot\rho\vec{v} = 0$$

Momentum Equation

$$\rho\left(\partial_t + \vec{v}\cdot\vec{\nabla}\right)\vec{v} = -\vec{\nabla}P - \rho\vec{\nabla}\Phi_g$$

$$\rho\left(\vec{v}\cdot\vec{\nabla}\right)\vec{v} = -\vec{\nabla}\left(K\rho^{1+\frac{1}{n}}\right) - \rho\vec{\nabla}\left(-G\int\frac{\rho}{\vec{r}-\vec{r}'}d^3x\right)$$

- Assumptions:
  - Time independence, local thermal equilibrium, cylindrical rotation, axial symmetry.
- Consequences:
  - guarantee mass and energy equations are identically satisfied, time derivatives become zero, and z and phi derivatives may be removed.

Polytropic Equation

$P = K\rho^{(1+1/n)}$

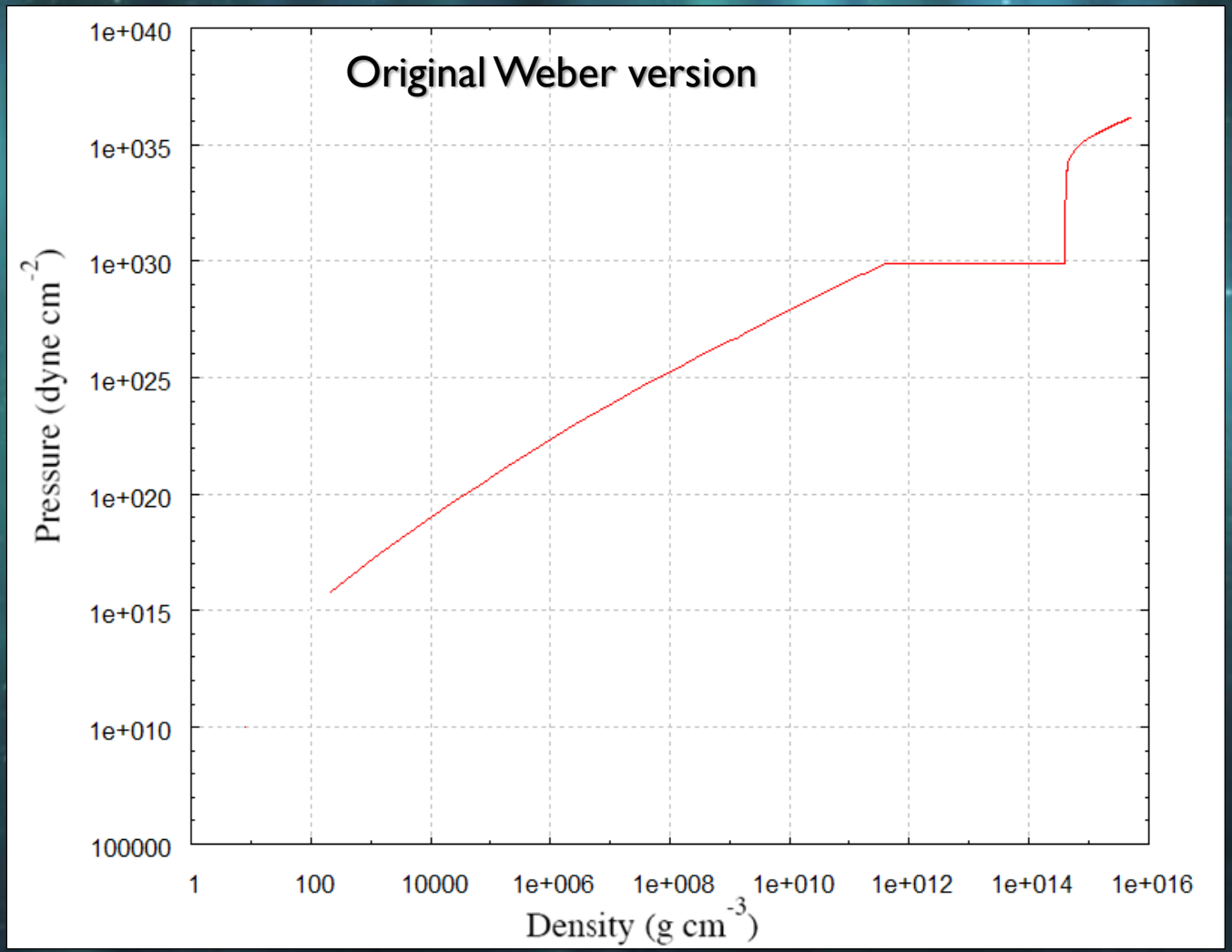
Gravitational Potential

$\Phi_g = -G\int\rho d^3x/|r-r'|$

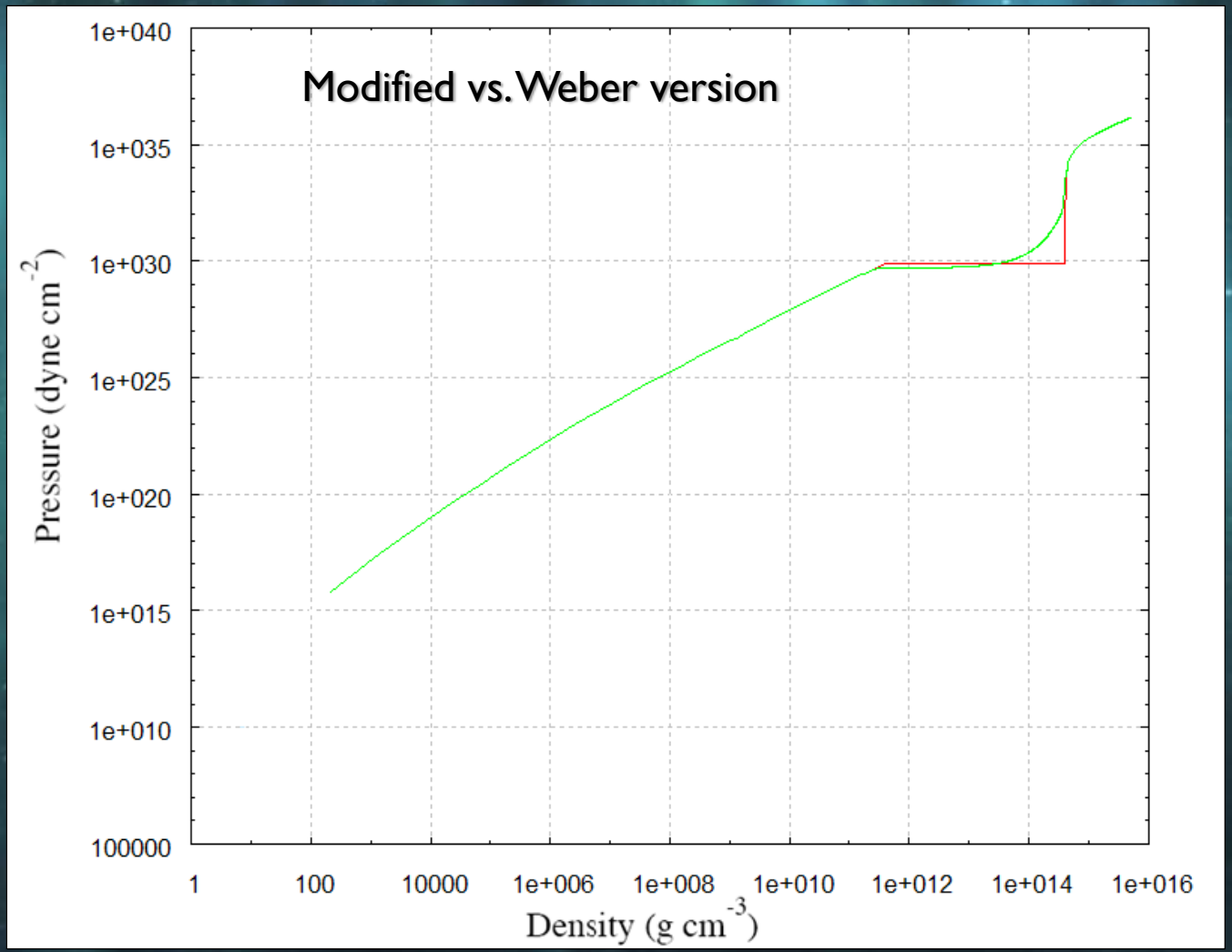
Self-Consistent Field Method

- Guess density
- Solve for gravitational potential and velocity field
- Get enthalpy
- Solve for a new density
- Compare to original density
- Reiterate until the difference is small

Equation of State

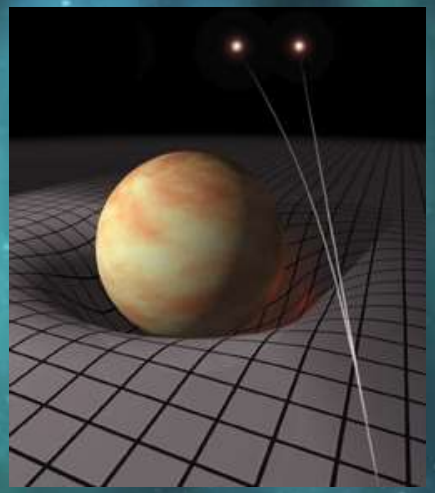


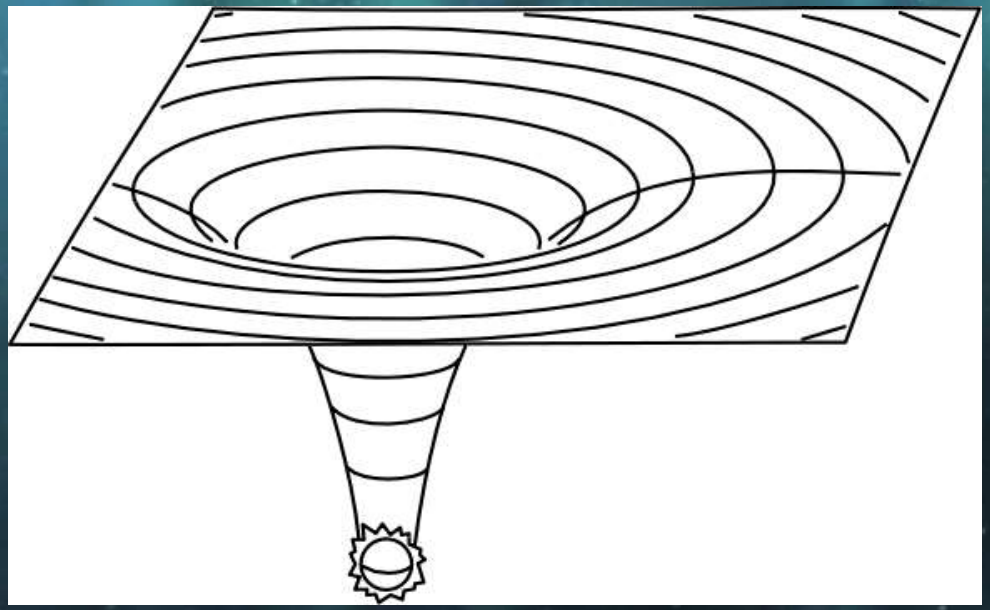
Equation of State



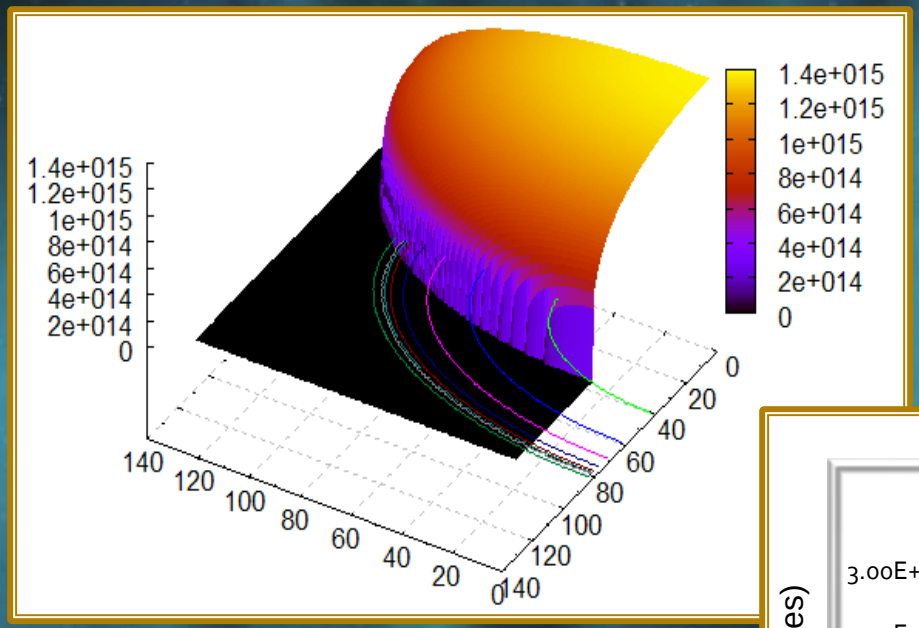
Future Refinement

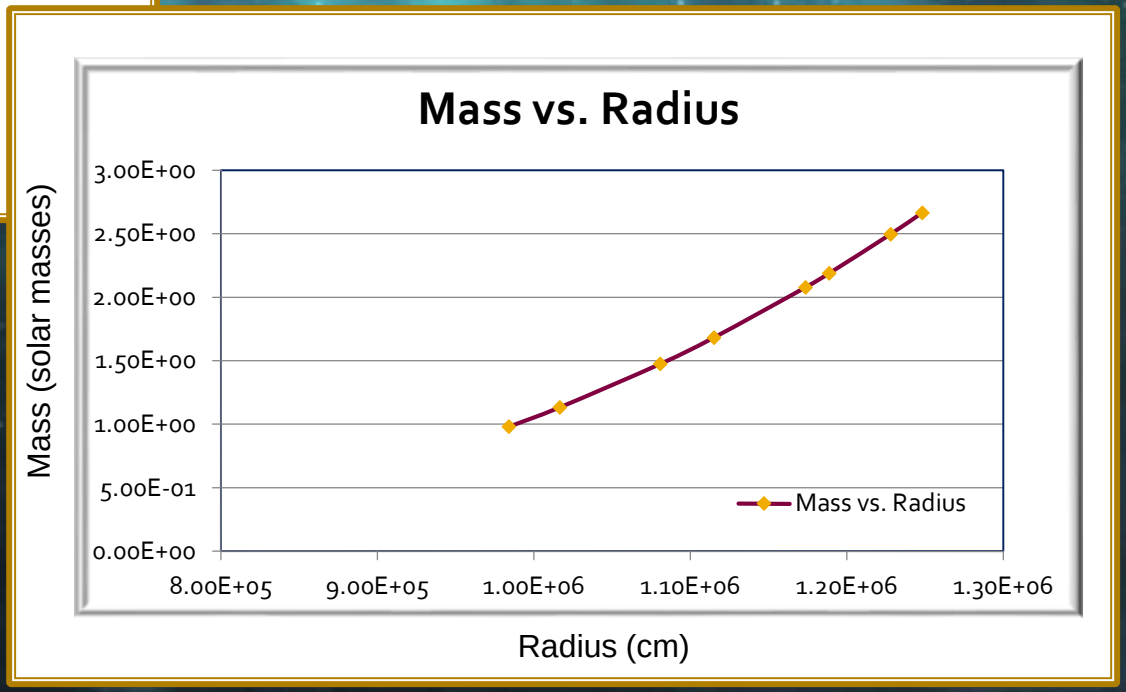
- Newtonian Code
  - Limitations of code.
- General Relativistic Code
  - Importance of incorporating the curvature of space-time.



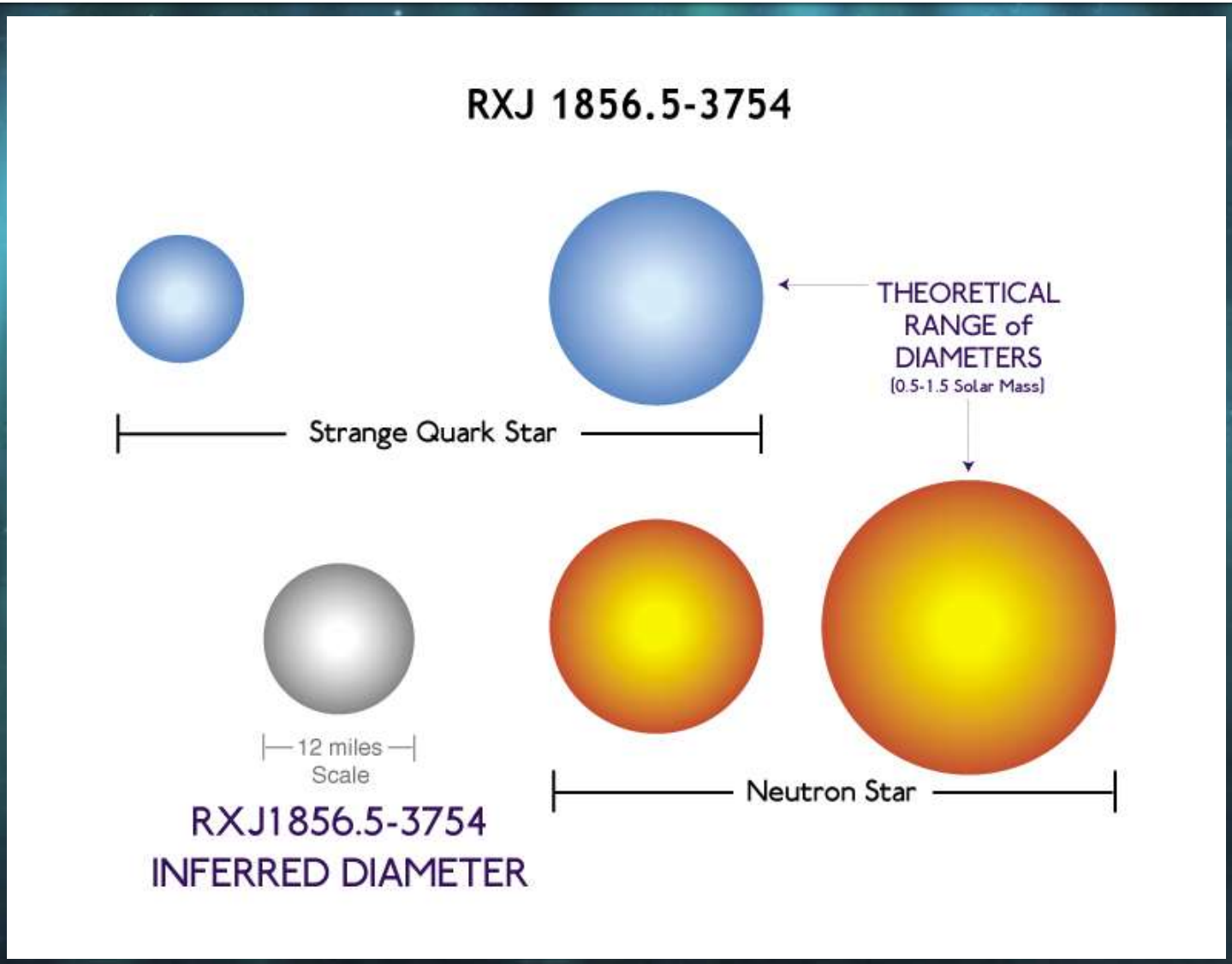


Analysis and Results





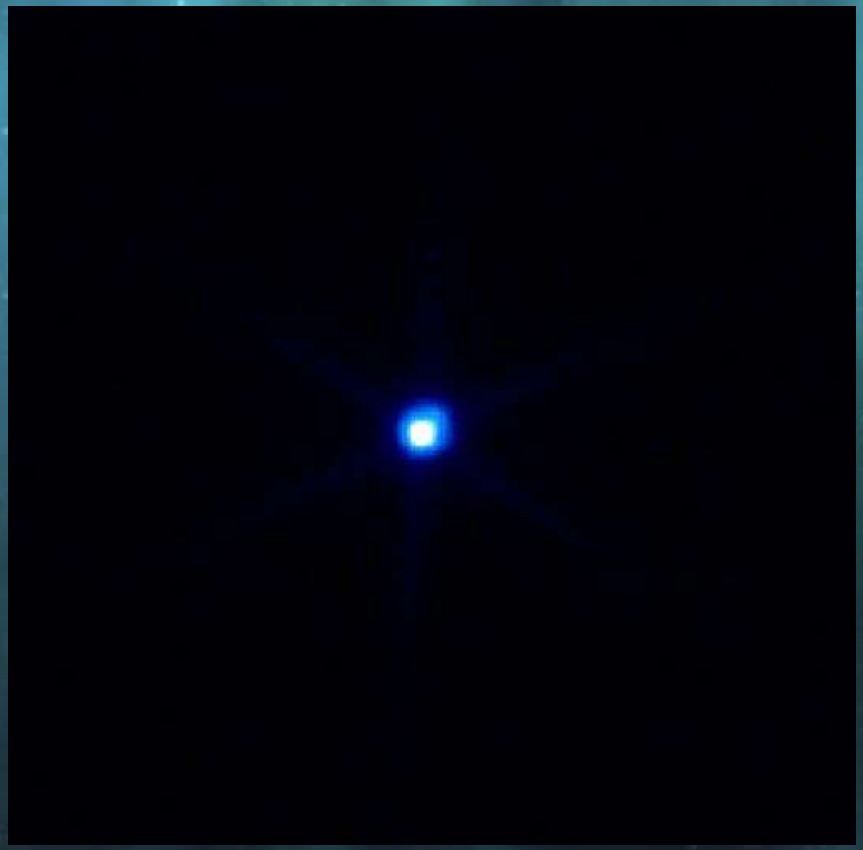
Observational Data



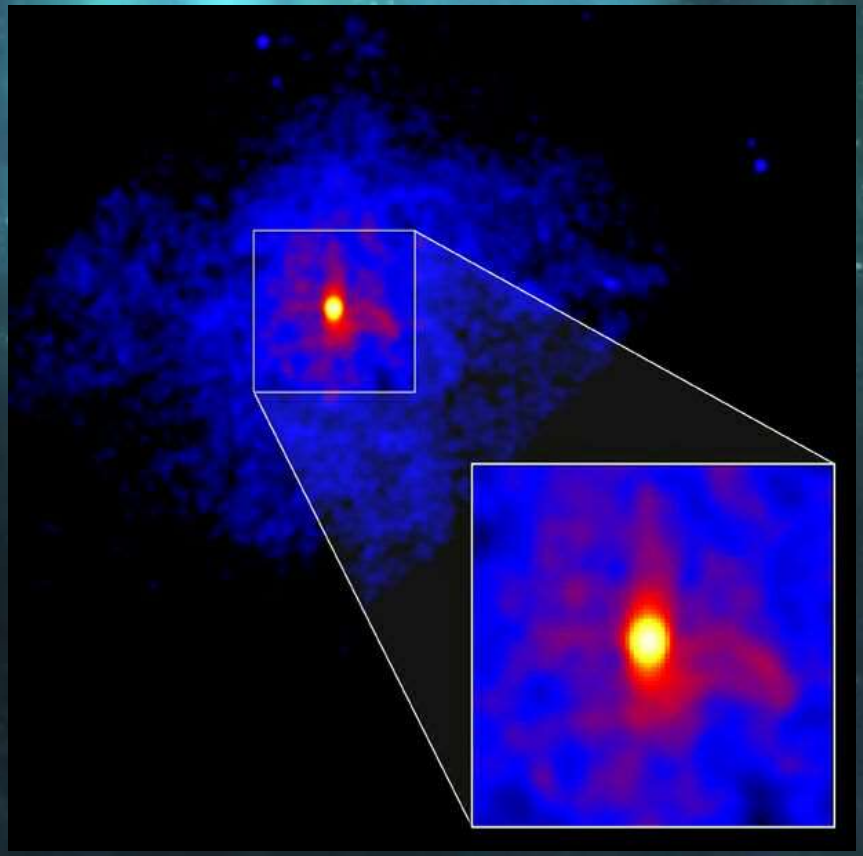
Observational Data

- Candidates for quark stars:

RX J1856.5-3754
neutron star/quark star



3C58
pulsar/quark star



Applications

- Possible applications for our work
  - Explanation for Gamma ray bursts?
    - poorly understood extremely luminous, high energy events producing flashes of gamma rays..
    - Occur during phase transition between neutron stars and strange quark stars?
    - Collapse releases the difference in binding energies.

Acknowledgments:

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