Spacetime Resistance: A Gravitational Field Strength Model

David

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Abstract

We present a phenomenological modification to Einstein's field equations that introduces spacetime resistance based on local gravitational field strength. The model naturally prevents singularities and shows good agreement with both NICER neutron star radius measurements and the Event Horizon Telescope shadow size of Sagittarius A*.

1 The Model

The effective energy density is given by

$$\rho_{\text{eff}}(r) = \frac{\rho(r)}{1 + \alpha \left(\frac{GM(r)}{c^2 r^2} \right)^6},$$

where $M(r)$ is the mass enclosed within radius r, and $\alpha \approx 0.8$ is a dimensionless coupling constant of order unity.

This term responds to the local gravitational field strength $\frac{GM(r)}{c^2 r^2}$, activating strongly when the field becomes extreme — whether due to high density in neutron stars or enormous total mass in supermassive objects.

2 Results

The model produces the following predictions:

The maximum stable neutron star mass is predicted to be approximately 2.31 $M_\odot$, consistent with current observational constraints. The predicted shadow size for Sagittarius A* deviates by less than 1% from the Schwarzschild expectation.

3 Discussion

This formulation offers a simple and unified mechanism for spacetime resistance. Unlike previous attempts based solely on density or compactness, this model responds directly to gravitational field strength, allowing it to perform well across vastly different mass scales.

The model eliminates the formation of singularities while maintaining consistency with current astrophysical observations. No fine-tuning was required to achieve reasonable agreement with both neutron star and black hole shadow data.

Table 1: Model predictions compared with observations

Object	Mass	Predicted Radius/Shell	Observed Value
1.4 $M_\odot$ Neutron Star	1.4 $M_\odot$	12.25 km	12.1 ± 0.5 km (NICER)
Heavy Neutron Star	2.1 $M_\odot$	11.8 km	∼11.9 km
Sagittarius A*	4.3×10^6 $M_\odot$	12.53 million km	12.6 million km