Spacetime Stiffness and the *ab*-Field: Recasting Einstein's Coupling Constant into a Measurable Framework

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Abstract

We introduce a new dimensional constant characterizing the stiffness of spacetime, derived directly from Einstein's gravitational coupling constant. Defining

$$\phi = \frac{c^2}{\sqrt{G}},$$

with units $\mathrm{kg}^{1/2}\,\mathrm{m}^{1/2}\,\mathrm{s}^{-1}$, we identify spacetime stiffness as the square root of force. From this, a scalar field

$$ab = \phi c^2$$

is defined, with units $\mathrm{kg}^{1/2}\,\mathrm{m}^{5/2}\,\mathrm{s}^{-3}$. A Klein–Gordon type dynamics for ab is derived, dimensionally verified, and mapped to laboratory observables such as cavity energy, effective length, and refractive index gradients. This reframing of $\kappa = 8\pi G/c^4$ emphasizes stiffness and compliance rather than exotic negative energy, providing a practical pathway to connect Einstein's equations with measurable engineering parameters.

Keywords: spacetime stiffness, Planck force, ab-field, Klein–Gordon equation, general relativity, maximum tension principle, warp metrics

1 Introduction

Einstein's field equations [1] encode gravity as the curvature of spacetime sourced by energy-momentum:

$$G_{\mu\nu} = \kappa T_{\mu\nu}, \qquad \kappa = \frac{8\pi G}{c^4}. \tag{1}$$

Here $G_{\mu\nu}$ is the Einstein tensor, $T_{\mu\nu}$ the stress-energy tensor, G Newton's constant, and c the speed of light. The coupling constant κ has long been recognized as dimensionally correct but opaque in meaning. What does it physically represent?

Planck [2] introduced natural units in 1899, including the *Planck force* $F_P = c^4/G$, a natural maximum stress scale of spacetime. Gibbons [3] later proposed the maximum tension principle, stating no force in nature can exceed F_P. This interpretation ties GR to an absolute stiffness of spacetime, yet this view remains underexplored.

This work proposes a redefinition of Einstein's coupling through a stiffness constant

$$\phi = \frac{c^2}{\sqrt{G}}, \tag{2}$$

and from it, the scalar field $ab = \phi c^2$. The aim is to reframe GR couplings in terms of stiffness, compliance, and measurable laboratory parameters.

2 Background and Literature

The idea of spacetime stiffness has echoes throughout physics. The Planck force $F_P = c^4/G$ emerges naturally from dimensional analysis [2, 4, 5]. Gibbons [3] provided a strong argument that this represents the maximum tension principle of general relativity. Alcubierre's warp metric [6] and White's work [7] highlighted the challenge of exotic negative energy in engineering applications, sparking alternative approaches.

Recent works such as Bini et al. [8] investigate generalized couplings between matter and gravity, suggesting deeper structures may underlie κ. The reframing in this paper connects those ideas to experimental observables: cavities, plasmas, and metamaterials.

3 Mathematical Framework

3.1 Definition of Stiffness Constant

Define

$$\phi = \frac{c^2}{\sqrt{G}}.$$

Dimensional analysis:

$$\frac{(m^2 s^{-2})}{(m^3 kg^{-1} s^{-2})^{1/2}} = kg^{1/2} m^{1/2} s^{-1},$$

which equals $\sqrt{\mathrm{N}}$, the square root of force. Numerically:

$$\phi = 1.10 \times 10^{22}.$$

3.2 Definition of the ab-field

Define

$$ab = \phi c^2.$$

Units:

$$(kg^{1/2} m^{1/2} s^{-1})(m^2 s^{-2}) = kg^{1/2} m^{5/2} s^{-3}.$$

Numerically:

$$ab = 9.89 \times 10^{38}.$$

3.3 Field Dynamics

We propose the action

$$S = \int \left[\tfrac{1}{2}(\partial_t ab)^2 - \tfrac{1}{2}c^2(\nabla ab)^2 - \tfrac{1}{2}\phi^2 ab^2 + Sab\right] d^4x. \tag{3}$$

Variation yields

$$\frac{\partial^2 ab}{\partial t^2} - c^2\nabla^2 ab + \phi^2 ab = S, \tag{4}$$

a Klein–Gordon type wave equation. Thus ab acts as a dynamical scalar field.

4 Volume Integral Quantities

To quantify corridor energies we use a C^∞ bump function

$$\alpha(r) = \alpha_0 \exp\left[-\frac{1}{1-\left(\frac{r-r_0}{\Delta r}\right)^2}\right],$$

and define

$$VIQ = \int_{r_0-\Delta r}^{r_0+\Delta r} \alpha(r)^2\, 4\pi r^2 dr. \tag{5}$$

Substitution $x = (r-r_0)/\Delta r$ gives

$$VIQ \approx 4\pi r_0^2 \alpha_0^2 \Delta r \int_{-1}^{1} \exp\left[-\tfrac{2}{1-x^2}\right] dx.$$

The definite integral evaluates to 0.133. For $r_0 = 1\,\mathrm{m}$, $\Delta r = 0.1\,\mathrm{m}$, $\alpha_0 = 1$, we obtain

$$VIQ = 0.167\,\mathrm{m}^3.$$

5 Experimental Mapping

From cavity energy

$$U_{\text{cav}} = \tfrac{1}{2}\epsilon_0 E^2 V,$$

we propose

$$ab \sim c^2\sqrt{\epsilon_0}E_{\text{rms}}\sqrt{VL_{\text{eff}}}.$$

For $E_{\text{rms}} = 10^6$ V/m, $V = 1\,\mathrm{m}^3$, $L_{\text{eff}} = 1\,\mathrm{m}$,

$$ab \approx 2.67 \times 10^{17}.$$

For metamaterials,

$$ab \sim c^2\phi\Delta n_{\text{eff}}\frac{L_{\text{eff}}}{L}.$$

These tie ab to Q, U_{cav}, and ∇n_{eff}.

6 Discussion

The stiffness constant ϕ reframes κ into an intuitive measure of resistance. The ab field provides a new scalar with its own dynamics. This opens new lines of research:

1. Testing ab-modulations in cavity experiments. 2. Exploring resonance with plasma oscillations. 3. Engineering metamaterials with measurable compliance to spacetime stiffness.

This interpretation moves the narrative from exotic energy toward compliance against stiffness, aligning with recent positive-energy approaches [7].

7 Future Work

Several paths forward exist:

- Perform VIQ scaling experiments with resonant cavities.
- Test ab predictions in strong-field laboratory plasmas.
- Map ϕ and ab directly into linearized Einstein equations.
- Explore whether ab contributes to dark energy or cosmological stiffness.

8 Conclusion

We introduced spacetime stiffness $\phi = c^2/\sqrt{G}$, with units $\sqrt{N}$. From this we defined $ab = \phi c^2$, with Klein–Gordon dynamics. Dimensional checks and numerical evaluations confirm consistency. Mapping ab to cavities and metamaterials ties abstract constants to laboratory observables. This framework recasts general relativity's coupling in engineering terms and opens pathways to experimental exploration.

References

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