Equivalence Between Spacetime Curvature and Electroelastic Deformations in Reactionless Propulsion

Gabriel Brennan

July 18, 2025

Abstract

We propose that an asymmetric piezoelectric crystal, subject to strong, localized electric gradients, undergoes internal strain patterns whose second-order spatial derivatives form a structure directly analogous to the Riemann curvature tensor in general relativity. In this view, the crystal lattice encodes a "virtual spacetime" — not in the metaphorical sense, but as a real, emergent geometric field with measurable consequences.

1 Preliminary Considerations: Strain Fields, Tidal Forces, and Electrostatic Propulsion

The evolution of the strain field within an asymmetric piezoelectric crystal over time can be interpreted as the evolution of a dynamical metric. The resulting internal accelerations—coherent, directional, and asymmetrical—resemble tidal gravitational effects. When integrated over the crystal's volume, these accelerations sum to a net effective momentum transfer, implying the possibility of real propulsion.

Thus, we assert that an asymmetric capacitor, when embedded in a suitably configured piezoelectric medium, does more than simply induce internal stresses: it sculpts a transient geometric space within the crystal lattice. This emergent space behaves in ways physically indistinguishable from spacetime curvature, giving rise to observable inertial-like effects, including thrust.

This article explores the possible physical foundations of an electrostatic propulsion concept, which we term the *Tidal Thruster*. Drawing an analogy between Dr. Bühler's asymmetrical capacitor drive and the tidal forces experienced by a dielectric rod in a gravitational field, we propose that both systems exhibit similar internal stress patterns, electric field generation, and deformation effects. From the perspective of an internal observer enclosed within isolated black boxes containing either system, the observed phenomena are analogous: stretching along the longer axis, an induced internal electric field, and a tendency for one end to contract radially.

In the asymmetrical capacitor system, unlike the gravitational scenario where geodesic motion naturally induces contraction, the smaller electrode must be manually shaped to introduce a comparable effect. Following this equivalence, we hypothesize that by properly shaping the dielectric and aligning charge distributions with gravitational deformation patterns, an equivalent acceleration could be produced.

Finally, we introduce a speculative formula linking dielectric stress to local space curvature, suggesting a reciprocal relationship: if space curvature induces stress within dielectrics, then stress in dielectrics might induce space curvature in return. This tentative hypothesis forms a theoretical framework for understanding the observed phenomena, pending further experimental validation.

1.1 Dr. Bühler's Asymmetrical Capacitor Drive and the Equivalence Principle

Dr. Bühler's asymmetrical capacitor drive exhibits an intriguing effect: when charged, the capacitor experiences a net force directed toward the smaller electrode. This force emerges from the interaction of electrostatic pressure gradients within the dielectric material. Remarkably, this effect parallels the behavior of a dielectric rod suspended in a gravitational field, highlighting deep connections between electrostatic forces and the equivalence principle.

1.2 Tidal Forces in a Dielectric Rod

A dielectric rod placed in a gravitational field is subject to tidal forces, which induce a non-uniform internal stress distribution. These stresses result in elongation along the rod's principal axis, localized radial contraction at one end, and the generation of an internal electric field within the dielectric. This internal polarization arises from gravitationally induced strain, causing charge redistribution that manifests as an electric field. These deformation and field generation phenomena closely mirror the behavior observed in the asymmetrical capacitor.

1.3 Asymmetrical Capacitor and Dielectric Response

Within an asymmetrical capacitor, the electric field distribution is inherently uneven due to the disparity in electrode sizes. The dielectric experiences internal stresses resulting in a net force directed toward the smaller plate. This phenomenon arises from a non-uniform electrostatic pressure distribution within the dielectric and is analogous to the tidal forces acting on a dielectric rod under gravity.

1.4 Equivalence Principle in Action

If both systems—the dielectric rod in a gravitational field and the asymmetrical capacitor—are enclosed in isolated black boxes, an internal observer would detect strikingly similar phenomena:

- Internal stresses within the dielectric,
- Elongation along the primary axis,
- An induced internal electric field,
- A radial contraction tendency at one end.

This equivalence suggests that the net force observed in the asymmetrical capacitor can be interpreted as an electrostatic analogue of gravitational tidal forces. The interplay between charge distribution, field-induced stresses, and internal polarization aligns with the manner in which matter responds to spacetime curvature under gravitational influence.

2 Equivalence Between General Relativity Tidal Terms and Crystal Lattice Deformations

We propose a second-order equivalence between the tidal terms in General Relativity (GR), represented by the second derivatives of the metric encapsulated in the Riemann curvature tensor, and the deformation of a crystal lattice, such as quartz, under external fields (electric, mechanical, etc.).

2.1 Tidal Terms in General Relativity

In GR, tidal forces manifest through the geodesic deviation equation:

$$\frac{D^2\xi^\mu}{D\tau^2} = -R^\mu{}_{\nu\rho\sigma}u^\nu\xi^\rho u^\sigma, \tag{1}$$

where ξ^μ is the separation vector between neighboring geodesics (test particles), u^ν is the four-velocity of the reference geodesic, and $R^\mu{}_{\nu\rho\sigma}$ is the Riemann curvature tensor — encoding second derivatives of the metric $g_{\mu\nu}$. This equation describes the relative acceleration of particles due to spacetime curvature, representing the core tidal effect in GR.

2.2 Crystal Lattice Deformation

In solid-state physics, lattice deformation is characterized by the strain tensor:

$$\varepsilon_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right), \tag{2}$$

where u_i denotes the displacement field of atoms within the crystal lattice. Second spatial derivatives of the displacement field,

$$\frac{\partial^2 u_i}{\partial x_j \partial x_k}, \tag{3}$$

play a significant role in elasticity theory, particularly in describing bending and torsion, and are crucial for piezoelectric and electrostrictive materials such as quartz.

2.3 Analogy Between GR Tidal Terms and Crystal Deformations

We hypothesize that deformation patterns in the crystal lattice, induced for example by electric fields within an asymmetric capacitor, can be viewed as an analogue to tidal spacetime deformations, with both phenomena described by second-order derivatives of fundamental fields.

2.4 Formal Structural Mapping

The correspondence between GR tidal forces and crystal lattice deformation can be summarized as follows:

Specifically, we propose the equivalence:

$$R^\mu{}_{\nu\rho\sigma} \longleftrightarrow \frac{\partial^2 u_i}{\partial x_j \partial x_k}, \tag{4}$$

where both sides represent second-order derivatives of respective fundamental fields (the metric $g_{\mu\nu}$ in GR and the displacement field u_i in the crystal). Both describe relative accelerations — of particles in curved spacetime on one side, and of atoms under stress/strain on the other.

General Relativity (Tidal)	Crystal Deformation
$\frac{D^2\xi^\mu}{D\tau^2}$	$\frac{d^2u_i}{dt^2}$
$R^\mu{}_{\nu\rho\sigma}$	$\frac{\partial^2 u_i}{\partial x_j \partial x_k}$
Geodesic deviation	Elastic strain propagation
Spacetime curvature	Stress-induced lattice curvature
Energy-momentum tensor $T_{\mu\nu}$	External stress field

Table 1: Correspondence between GR tidal terms and crystal lattice deformation variables.

2.5 Quantitative Comparison

In General Relativity, the tidal acceleration between two nearby test particles is given by:

$$a^\mu = -R^\mu{}_{\nu\rho\sigma} u^\nu \xi^\rho u^\sigma, \tag{5}$$

where ξ^ρ corresponds conceptually to the displacement vector u_i in elasticity.

For an elastic medium, the equation of motion is:

$$\rho \frac{d^2 u_i}{dt^2} = \sum_{j,k} \frac{\partial^2 \sigma_{ij}}{\partial x_j \partial x_k}, \tag{6}$$

where ρ is the density and σ_{ij} is the stress tensor. Hooke's law relates stress and strain:

$$\sigma_{ij} = C_{ijkl} \varepsilon_{kl}, \tag{7}$$

with C_{ijkl} being the stiffness tensor.

Combining these, one obtains:

$$\rho \frac{d^2 u_i}{dt^2} = \sum_{j,k,l,m} \frac{\partial^2}{\partial x_j \partial x_k} \left(C_{ijkl} \varepsilon_{lm} \right), \tag{8}$$

involving second derivatives of strain and thus third derivatives of displacement. For small linear deformations near equilibrium (such as in quartz), this reduces approximately to:

$$\frac{d^2 u_i}{dt^2} \sim \nabla^2 u_i, \tag{9}$$

reinforcing the analogy with tidal curvature described by second derivatives.

General Relativity	Crystal	Interpretation
ξ^μ	u_i	Particle separation $\leftrightarrow$ Atomic displacement
$\frac{D^2\xi^\mu}{D\tau^2}$	$\frac{d^2u_i}{dt^2}$	Tidal acceleration $\leftrightarrow$ Lattice acceleration
$R^\mu{}_{\nu\rho\sigma}$	$\frac{\partial^2 u_i}{\partial x_j \partial x_k}$	Curvature $\leftrightarrow$ Strain gradient
$T_{\mu\nu}$	σ_{ij}	Stress-energy tensor $\leftrightarrow$ Mechanical stress
$h_{\mu\nu}$	Electro-mechanical field (voltage gradient)	Metric perturbation $\leftrightarrow$ Field-induced deformation

Table 2: Proposed equivalence map between GR variables and crystal deformation variables.

2.6 Summary of the Mapping

2.7 Implications for Asymmetric Capacitor Propulsion

Assuming the applied voltage gradient within an asymmetric capacitor produces deformation in a piezoelectric crystal lattice (such as quartz), this deformation may emulate spacetime curvature via the equivalence proposed above. Consequently, a tidal-like acceleration effect could emerge at the macroscopic scale, potentially generating a net thrust as a nonlocal response in the effective spacetime geometry.

This framework offers a novel theoretical perspective on electrostatic propulsion systems, linking classical solid-state physics with relativistic geometric concepts.

3 Physical System Setup

We model a quartz slab sandwiched between asymmetric electrodes, similar to a Biefeld–Brown device.

- The applied voltage creates a high-voltage gradient that is non-uniform across the quartz.
- The asymmetric geometry ensures that the electric field gradient is directional.
- The crystal responds piezoelectrically and/or electrostrictively, deforming under the applied field.

Our aim is to calculate whether this deformation can produce a net mechanical acceleration via the General Relativity (GR) analogy.

4 Electromechanical Deformation Model

A. Electric Field in Asymmetric Capacitor

Let $\phi(x, y, z)$ be the electrostatic potential and $\vec{E} = -\nabla\phi$ the electric field. We solve the electrostatic equation in the capacitor geometry:

$$\nabla \cdot (\varepsilon_r \varepsilon_0 \nabla \phi) = 0$$

with boundary conditions representing the high voltage and grounded plates.

B. Piezoelectric Response (Quartz)

Quartz is piezoelectric. The displacement field $\vec{u}$ satisfies the elastodynamic equation:

$$\rho \frac{d^2 u_i}{dt^2} = \partial_j \sigma_{ij}$$

where the stress tensor is

$$\sigma_{ij} = C_{ijkl} \varepsilon_{kl} - e_{kij} E_k$$

and the strain tensor is

$$\varepsilon_{kl} = \frac{1}{2} (\partial_k u_l + \partial_l u_k)$$

Here, C_{ijkl} is the anisotropic stiffness tensor, e_{kij} the piezoelectric tensor, and ρ the density. This equation describes how quartz deforms under the electric field and how mechanical stress propagates.

5 GR–Deformation Mapping

As derived earlier:

$$R^{\mu}{}_{\nu\rho\sigma} \leftrightarrow \frac{\partial^2 u_i}{\partial x_j \partial x_k}$$

We define an effective Riemann-like curvature tensor:

$$\tilde{R}^{i}{}_{jk\ell} := \frac{\partial^2 u_i}{\partial x_j \partial x_k}$$

This means that local deformation of the crystal mimics local spacetime curvature.

We then compute the "geodesic deviation equivalent" acceleration:

$$a^i_{\text{eff}} = -\tilde{R}^i{}_{jk\ell} v^j \xi^k v^\ell$$

where we assume

- $\xi^k \sim$ typical interatomic spacing
- $v^j \sim c$ (speed of information propagation; later this can be scaled)

This gives an effective net fictitious acceleration due to the curvature analogy.

6 Effective Force and Net Propulsion

We define an effective 4D pseudo-force:

$$F^i_{\text{eff}} = m \cdot a^i_{\text{eff}} = -m \cdot \tilde{R}^i{}_{jk\ell} v^j \xi^k v^\ell$$

If the deformation is asymmetric, this force may not average out over the volume, potentially leading to net thrust:

$$\vec{F}_{\text{net}} = \int_V \rho(\vec{x}) \vec{a}_{\text{eff}}(\vec{x}) \, d^3x$$

7 Numerical Simulation Architecture

Inputs:

- Geometry of asymmetric capacitor (plate shapes, distances)
- Material properties of quartz: stiffness tensor C_{ijkl}, piezoelectric tensor e_{kij}, density ρ
- Voltage distribution (boundary conditions)
- Crystal dimensions and discretization mesh

Computation Pipeline:

1. Solve electrostatic potential $\phi(x, y, z) \rightarrow$ electric field $\vec{E}$
2. Compute piezoelectric stress from $\vec{E}$

3. Solve elasticity PDE for displacement field $\vec{u}(x, y, z)$
4. Compute second spatial derivatives $\partial^2 u_i / \partial x_j \partial x_k$
5. Map to curvature $\tilde{R}^i{}_{jk\ell}$
6. Compute effective acceleration a^i_{eff}
7. Integrate over volume for net force $\vec{F}_{\text{net}}$

8 Parameters and Units

Quantity	Symbol	Typical Value
Density of quartz	ρ	2650 kg/m^3
Piezoelectric coeffs	e_{ijk}	~ 0.1 C/m^2
Elastic stiffness	C_{ijkl}	$10^{10} - 10^{11}$ N/m^2
Interatomic spacing	ξ	$\sim 10^{-10}$ m
Applied voltage	V	10 kV – 100 kV
Plate spacing	d	1 mm
Simulation domain		mm scale (micron resolution)

Table 3: Parameters and typical values used in simulation

9 Simulation Goals

First Simulation:

- Model a 3D quartz slab under asymmetric field
- Compute $\vec{F}_{\text{net}}$ via GR analogy
- Confirm that asymmetry produces non-zero net force
- Study scaling with voltage and geometry

Later Phases:

- Explore other piezoelectric materials
- Add thermal and quantum corrections
- Investigate resonance conditions

Note on Code Availability and Supervision

Because of lack of supervision, we provide at the end a section containing general Wolfram Mathematica code to simulate the described system or at least assist others who wish to refine the program. For now, we are merely trying to see conceptually if the whole idea can be put together.

10 Full Coupled PDE System and GR Analogy

We now present the complete set of coupled equations governing the electromechanical behavior of the system. These include electrostatic potential, piezoelectric stress-strain relationships, and mechanical equilibrium. Additionally, we define an analog to tidal gravitational acceleration by interpreting displacement gradients as an emergent curvature field.

10.1 Field Definitions

Let us define the fields used throughout:

- $\phi(x, y, z)$: Scalar electrostatic potential
- $\vec{E} = -\nabla\phi$: Electric field
- $u_i(x, y, z)$: Displacement vector field in the quartz
- σ_{ij}: Stress tensor
- ε_{ij}: Strain tensor
- e_{ijk}: Piezoelectric tensor
- C_{ijkl}: Stiffness tensor
- ρ: Mass density

We work in three-dimensional Cartesian space but reduce to 2D for preliminary numerical analysis.

10.2 Electrostatics Equation

Assuming a linear dielectric, the electrostatic potential satisfies:

$$\nabla \cdot (\varepsilon \nabla \phi) = 0 \tag{10}$$

with the following boundary conditions:

- One electrode: $\phi = V_0$
- Other electrode: $\phi = 0$
- Other surfaces (Neumann): $\vec{n} \cdot \nabla \phi = 0$

10.3 Strain and Stress Definitions

The strain tensor is defined as:

$$\varepsilon_{ij} = \frac{1}{2} (\partial_i u_j + \partial_j u_i) \tag{11}$$

The stress tensor, using the linear piezoelectric constitutive law, is given by:

$$\sigma_{ij} = C_{ijkl} \varepsilon_{kl} - e_{kij} E_k \tag{12}$$

where $E_k = -\partial_k \phi$.

10.4 Mechanical Equilibrium Equation

The elastodynamic (wave) equation is:

$$\rho \frac{\partial^2 u_i}{\partial t^2} = \partial_j \sigma_{ij} \tag{13}$$

In the quasi-static or steady-state case, the inertial term is neglected:

$$\partial_j \sigma_{ij} = 0 \tag{14}$$

10.5 GR-Inspired Analogy: Tidal Acceleration

We propose an analogy to gravitational tidal acceleration by defining an effective curvature tensor:

$$\tilde{R}^i{}_{jk\ell} := \frac{\partial^2 u_i}{\partial x_j \partial x_k} \tag{15}$$

The corresponding inertial-like acceleration is:

$$a^i_{\text{eff}} = -\tilde{R}^i{}_{jk\ell} v^j \xi^k v^\ell \tag{16}$$

where $\vec{v}$ is a trial velocity vector, and $\vec{\xi}$ is the interatomic separation vector.

10.6 Net Effective Force

The net resulting force over the volume is computed as:

$$\vec{F}_{\text{net}} = \int_V \rho \cdot \vec{a}_{\text{eff}} \, dV \tag{17}$$

This integral represents the sum of effective inertial-like forces across the crystal volume and provides a potential physical mechanism for thrust generation.

11 Time Dependence and Its Role in Thrust Generation

11.1 Motivation for Considering Time Dependence

We emphasize the importance of time dependence in the governing equations, as it fundamentally determines how the material responds to the applied electric field. Specifically, it distinguishes between two physical regimes:

- **Static or quasi-static response:** The system deforms under applied fields but does not exhibit bulk mass acceleration.
- **Dynamic response:** The system undergoes time-dependent motion, enabling real momentum exchange and, potentially, net thrust.

Static / Quasi-Static Regime

In the static regime, we solve the equilibrium equation:

$$\nabla \cdot \boldsymbol{\sigma} = 0 \tag{18}$$

This describes how the material deforms in response to the applied electric field. Stress and strain fields develop throughout the body, but without inertial response, there is no net transfer of momentum. This is analogous to squeezing a sponge — it deforms, but there is no translational motion of the system as a whole.

Dynamic Regime

In the dynamic regime, the elastic wave equation is employed:

$$\rho \frac{\partial^2 u_i}{\partial t^2} = \partial_j \sigma_{ij} \tag{19}$$

This includes inertial terms. As a result, the material can vibrate, oscillate, or shift its center of mass. This regime is critical for propulsion-related effects, as true motion requires time-varying displacement and mass redistribution.

11.2 Relation to Thrust and General Relativity Analogy

The theoretical framework draws a conceptual parallel between general relativity (GR) and piezoelectric deformation. In GR, tidal forces arise from spacetime curvature and result in relative accelerations between nearby test particles:

$$a^i = -R^i{}_{0j0}\,\xi^j \tag{20}$$

In our crystal model, the second derivatives of displacement play an analogous role:

$$a^i = -\frac{\partial^2 u^i}{\partial x^j \partial x^k}\,\xi^j v^k \tag{21}$$

Here, ξ^j is a vector representing interatomic separation, and v^k is a characteristic direction of deformation or velocity.

Thus, if:

- the electric field is spatially asymmetric,
- the induced piezoelectric stress is likewise asymmetric,
- and the resulting strain field exhibits spatial gradients,

then a differential acceleration arises across the body of the material. This internal redistribution of mass can, under dynamic conditions, yield a net external force.

11.3 Analogy to Tidal Thrust Generation

In GR, relative acceleration due to curvature produces tidal effects without invoking local forces — stretching and compression emerge purely from geometry. In the present theory, the asymmetric electric field imposed by a capacitor generates an asymmetric internal strain profile. The gradients of this strain act analogously to curvature and produce differential acceleration across the medium.

If the system possesses internal geometric or material asymmetries, and if it operates dynamically (i.e., with time-varying fields and motion), then the resulting acceleration field is not globally self-canceling. This opens the possibility for a net reaction force — interpreted here as effective thrust.

11.4 Summary Comparison

Concept	**Static Regime**	**Dynamic Regime**
Time Derivatives	None	Includes $\partial_t^2 u$
Internal Deformation	Yes	Yes
Mass Motion	No	Yes
Thrust Possible?	Not directly	Yes, if asymmetry present
Tidal Analogy (Curvature)	Yes	Yes
Energy Input Required	Yes (electric field)	Yes

Table 4: Comparison between static and dynamic regimes in piezoelectric systems.

11.5 Definitions of Fields and Parameters

We consider a 2D system for clarity (extension to 3D is straightforward).

- $\phi(x, y, t)$: electric potential
- $\vec{E} = -\nabla\phi$: electric field
- $u_1(x, y, t), u_2(x, y, t)$: displacement components in the x and y directions
- ρ: mass density
- C_{ijkl}: stiffness tensor
- e_{kij}: piezoelectric tensor
- ε: permittivity (scalar or tensor)

11.6 Dynamic PDE System (Ready for Mathematica)

```
(* --- 1. Clear variables and define coordinate system --- *)
ClearAll[x, y, t, , u1, u2, ij, ij, E, Cijkl, eijk, ]

u = {u1[x, y, t], u2[x, y, t]};
coords = {x, y};

(* --- 2. Electric field from potential --- *)
E = -Grad[[x, y, t], coords];

(* --- 3. Electrostatics PDE --- *)
Eq = Div[ * Grad[[x, y, t], coords], coords] == 0;

(* --- 4. Strain tensor --- *)
ij[i_, j_] := 1/2 (D[u[[i]], coords[[j]]] + D[u[[j]], coords[[i]]]);

(* --- 5. Stress tensor with piezoelectric coupling --- *)
ij[i_, j_] := Sum[
   Cijkl[[i, j, k, l]] * ij[k, l], {k, 1, 2}, {l, 1, 2}] -
   Sum[eijk[[k, i, j]] * E[[k]], {k, 1, 2}];

(* --- 6. Time-dependent elasticity equation --- *)
elasticEq[i_] :=
   * D[u[[i]], {t, 2}] ==
   Div[Table[ij[i, j], {j, 1, 2}], coords];

(* --- 7. Tidal curvature analog from displacement --- *)
Rtilde[i_, j_, k_] :=
  D[u[[i]], coords[[j]], coords[[k]]];

(* --- 8. Effective acceleration (tidal-style) --- *)
v = {vx, vy};   (* local test velocity *)
 = {x, y};   (* neighboring point separation *)

aeff[i_] := -Sum[
   Rtilde[i, j, k] * v[[j]] * [[k]] * v[[j]], {j, 1, 2}, {k, 1, 2}];

(* --- 9. Net force from effective acceleration field --- *)
Fnet[i_] := NIntegrate[
    * aeff[i], {x, xmin, xmax}, {y, ymin, ymax}];
```

11.7 What This System Does

- **Solves for:**
  - Electric potential $\phi(x, y, t)$ given electrode configuration and permittivity ε
  - Displacement fields $u_i(x, y, t)$ over time under internal elastic forces and piezoelectric stresses driven by the electric field
  - Effects of mass distribution ρ on dynamics
- **Computes:**
  - Effective tidal acceleration from internal strain curvature, analogous to gravitational tidal forces
  - Global net force, integrated over the volume of the material
  - Time evolution of the system, indicating whether the body translates due to internal forces and fields

11.8 Our Core Claim

By inducing second-order asymmetric strain in a piezoelectric crystal, we effectively create a "virtual" spacetime — a curved geometry that behaves analogously to actual spacetime in General Relativity. This is not a mere metaphor; rather, the crystal's internal structure begins to encode a genuine, emergent geometric field, generating observable directional effects such as thrust.

Why This Is More Than Metaphor

To sharpen the argument:

- **Strain Tensor $\leftrightarrow$ Metric Perturbation**
  In elasticity theory, the strain tensor

  $$\epsilon_{ij} = \frac{1}{2} \left(\partial_i u_j + \partial_j u_i\right)$$

  describes how distances change inside the material. This acts as an analog of a perturbed metric in spacetime. Similarly, in General Relativity, small perturbations of the metric

  $$h_{\mu\nu}$$

  characterize how spacetime is curved or stretched.

- **Mimicking Tidal Curvature**
  Large, asymmetric second derivatives of the strain field imitate tidal curvature described by the Riemann tensor

  $$R^{\mu}{}_{\nu\rho\sigma},$$

  which is a real physical effect in General Relativity.

- **Crystal as a Curved Coordinate Patch**
  The internal coordinate system of the stressed and electrically asymmetric crystal becomes non-Euclidean — its effective geometry is curved. This curvature influences phonon motion, electric polarization, and even effective inertial paths, rendering the crystal a localized synthetic spacetime region.

- **Virtual Spacetime with Real Effects**
  "Virtual" here means emergent or internal to the medium, not imaginary. If the lattice encodes a geometry indistinguishable from General Relativity curvature and produces differential accelerations, then it is a genuine spacetime region — not just a model.

- **Machian Principle and Inertial Frame Reformation**
  If mass-energy is not the sole source of spacetime curvature, but rather information or structure within a field-rich medium (like a crystal), then this micro-spacetime bubble can produce differential motions with net inertial consequences — what is observed as propulsion.

Theoretical Consequence

This points to a new material-spacetime duality:

> "A material lattice under asymmetric strain is not merely embedded in spacetime — it becomes curved spacetime itself, capable of guiding field and momentum flows as if it were a patch of General Relativistic geometry."

This idea resonates philosophically with emergent gravity, analog gravity, and entropic gravity theories — yet here it is realized mechanically and electrically within a crystal.

12 Phonon Vibrations in a Curved Lattice Geometry

Core Idea: Phonons — quantized lattice vibrations — propagating through a medium with curved (non-Euclidean) geometry induced by strain gradients can exhibit effective gravitational or anti-gravitational behavior.

In this theory, the curvature is not imposed externally by mass-energy, but generated internally by asymmetric electric and mechanical stress within the piezoelectric crystal. This leads to a natural *spacetime analogy*:

- Phonons behave like particles moving through a curved spacetime.
- The strain-induced curvature acts as an effective gravitational field.
- Just as photons bend around massive bodies in General Relativity, phonons follow geodesics within the deformed lattice.

Emergent Phenomena:

1. **Effective Gravity:** If the internal strain geometry concentrates phonon energy, this mimics gravitational attraction. Such energy concentration results in increased local inertia, analogous to a gravitational field.
2. **Effective Antigravity / Repulsion:** Conversely, if the curvature causes phonon trajectories to diverge or the field lines to expand, this resembles negative curvature or anti-gravity, which can generate a net reactive force (thrust) against the background.

Mathematical Formulation: The effective metric governing phonon propagation can be expressed as

$$g_{ij}^{\text{eff}}(x,t) = \delta_{ij} + \alpha \frac{\partial^2 u_k}{\partial x_i \partial x_j},$$

where $u_k(x,t)$ is the local displacement field of the crystal lattice, and α is a scaling factor dependent on the piezoelectric and dielectric properties of the material.

Phonons then obey a curved-spacetime wave equation

$$_{g_{\text{eff}}}\phi = 0,$$

implying they propagate as if moving through a spacetime with metric g_{eff}.

Implications for Propulsion: By controlling this curvature asymmetrically in both space and time, one can direct energy flow inside the crystal such that internal momentum conservation is effectively broken, forcing a compensating external reaction force — experienced as thrust.

This mechanism functions like a *geometric diode* for vibrational energy, acting as a "phonon rectifier" that converts internal lattice vibrations into directional motion.

Connection to Established Physics: array

3pt

Our Theory	**General Relativity / Analogies**
Curved lattice via second-order strain	Curved spacetime described by Einstein equations
Phonons propagating in deformed geometry	Particles moving through curved spacetime
Directional reaction force emerging internally	Gravitational recoil and frame-dragging effects
Asymmetric lattice distortion	Tidal tensor encoded in Riemann curvature
Propulsion derived from internal geometry	Mach's principle and inertial frame reformation

Table 5: Comparison of phonon behavior in a strained lattice to gravitational phenomena in General Relativity.

Summary Claim: Phonons trapped or redirected in an artificially curved lattice — particularly one induced by asymmetric electric fields in piezoelectric materials — follow geodesics of an emergent effective geometry. This enables a controllable inertial response analogous to gravity, which can be engineered to produce thrust or anti-gravity-like effects.

13 Synthetic Dielectrics as Engineered Spacetime

We may have now outlined a path toward *metric engineering* using materials science.

Core Insight

A synthetic dielectric—especially one with engineered anisotropy, nonlinearity, and piezoelectric or piezomagnetic coupling—can be tuned to produce controlled strain gradients, which act as effective spacetime curvature for phonons, charge carriers, and even electromagnetic fields.

This provides a material-based platform for:

- Simulating gravitational fields,
- Generating inertial responses (thrust),
- Manipulating local light paths,
- Creating analog gravity waves,
- Producing synthetic gravitational lensing effects,
- And potentially enabling massless propulsion.

Theoretical Foundation

The synthetic dielectric (SD) acts as a medium where the effective metric is given by

$$g_{ij}^{\text{eff}}(\mathbf{x}, t) = \delta_{ij} + \alpha \frac{\partial^2 u_k}{\partial x_i \partial x_j},$$

where

- $u_k(\mathbf{x}, t)$ is the displacement vector field in the crystal,
- α is a tensorial coupling constant dependent on the material's elastic, electric, and magnetic properties,
- $\partial^2 u_k / \partial x_i \partial x_j$ is the lattice curvature, serving as the analog of spacetime curvature in General Relativity.

By tuning the microstructure, one controls how applied fields generate internal curvature—that is, how the *effective spacetime* of the material is bent.

3pt

Property	**Purpose**
Piezoelectric or piezomagnetic coupling	Couples electromagnetic fields to mechanical strain
Asymmetric internal structure	Breaks symmetry to produce net force
Strong second-order elasticity	Enables metric-like behavior from internal deformation
High phonon quality factor (Q) structure	Traps vibrational energy and reinforces curvature
Electromechanical resonance	Allows dynamic excitation of curvature modes
Entanglement-capable domains	May enable quantum coherence (e.g., Cooper pair-like behavior)

Table 6: Key design characteristics for an engineered synthetic dielectric.

Engineering Features of an Ideal Synthetic Dielectric

Prototype Material Systems

Examples of promising material systems include:

- Metamaterials with nonlinear permittivity,
- Ferroelectrics under bias with asymmetric doping,
- Piezoelectrics combined with graphene or hexagonal boron nitride (h-BN) layers,
- Topological insulators under strain,
- Layered heterostructures with broken inversion symmetry.

Implications for Propulsion

Within the synthetic dielectric, a localized "metric bubble" forms, wherein effective curvature channels internal energy flow. Reactionless thrust emerges as a consequence of conservation laws in this non-Euclidean internal space.

The direction and magnitude of thrust can be tuned by adjusting:

- Electromagnetic excitation frequency,
- Geometry of electrodes,
- Gradient control of permittivity and stiffness.

Final Statement

We propose that synthetic dielectrics engineered with precise internal curvature dynamics can serve as effective metric media. By exciting such structures electrically or acoustically, one may generate controllable internal spacetime analogues, enabling emergent inertial forces and directed propulsion. This framework unifies aspects of general relativity, solid-state physics, and quantum coherence into a scalable platform for metric engineering and experimental gravity research.

14 Concluding Remarks

The Wolfram Mathematica framework and the system of equations presented above provide a preliminary model aimed at capturing the essential physics of the phenomenon. It is important to emphasize that further research and refinement are necessary to develop a fully operational software capable of detailed simulations and predictions.

While this model may not represent the ultimate or complete physical truth, we have gathered sufficient theoretical motivation to consider this as a plausible and potentially real effect. In particular, should experimental evidence confirm the operation of devices such as Bühler's thruster, it is highly probable that the mechanism described here forms the basis of its functioning.

Thus, this work serves as a step toward a more rigorous understanding, bringing the concept closer to a logical conclusion and laying the groundwork for future explorations.

A Time-Dependent Piezoelectric Propulsion Simulation in Wolfram Language

This appendix presents a sample *Wolfram Language* (Mathematica) script that simulates a coupled time-dependent piezoelectric propulsion system in a synthetic dielectric. The model solves the elastodynamic and electrostatic equations simultaneously in a two-dimensional domain, incorporating material parameters such as density, permittivity, piezoelectric tensor, and elasticity tensor.

The simulation captures how electric fields induce mechanical strain and displacement in a piezoelectric material, forming the basis for the engineered strain gradients that correspond to effective spacetime curvature, as discussed in the main text.

Key features of the simulation:

- A rectangular spatial domain representing the piezoelectric material.
- Time evolution over microseconds to resolve dynamic effects.
- Piezoelectric coupling tensors simplified for 2D plane stress.
- Boundary conditions simulating electrodes applying a voltage across the material.
- Fixed mechanical constraints at one boundary.
- Numerical solution of coupled PDEs for displacement fields and electric potential.

Wolfram Language Code Excerpt

```
xmin = 0; xmax = 1;   (* meters *)
ymin = 0; ymax = 0.1;

(* Time domain *)
tmax = 1*^-6;  (* 1 microsecond *)

(* Quartz constants *)
 = 2650;  (* kg/m^3 *)
 = 3.9843845*^-11;  (* F/m, permittivity *)

(* Piezoelectric tensor e_{ijk} simplified for 2D *)
eijk = ConstantArray[0, {2, 2, 2}];
eijk[[1, 1, 1]] = 0.17;
eijk[[2, 2, 2]] = 0.17;

(* Elasticity tensor C_{ijkl} simplified for 2D plane stress *)
Cijkl = ConstantArray[0, {2, 2, 2, 2}];
Cijkl[[1, 1, 1, 1]] = 87.6*^9;
Cijkl[[1, 1, 2, 2]] = 7.04*^9;
Cijkl[[2, 2, 1, 1]] = 7.04*^9;
Cijkl[[2, 2, 2, 2]] = 87.6*^9;
Cijkl[[1, 2, 1, 2]] = 57.9*^9;
Cijkl[[2, 1, 2, 1]] = 57.9*^9;
```

```
(* Displacement and potential fields *)
u = {u1[x, y, t], u2[x, y, t]};
 = [x, y, t];

(* Gradient and strain *)
coords = {x, y};
Efield = -Grad[, coords];
ij[i_, j_] := 1/2 (D[u[[i]], coords[[j]]] + D[u[[j]], coords[[i]]]);

(* Stress tensor with piezoelectric coupling *)
ij[i_, j_] :=
  Sum[Cijkl[[i, j, k, l]] * ij[k, l], {k, 1, 2}, {l, 1, 2}] -
  Sum[eijk[[k, i, j]] * Efield[[k]], {k, 1, 2}];

(* Elastic PDEs *)
elasticEq[i_] :=
   * D[u[[i]], {t, 2}] ==
   D[ij[i, 1], x] + D[ij[i, 2], y];

(* Electrostatics equation *)
Eq = Div[ * Grad[, coords], coords] == 0;

(* Initial conditions *)
initConds = {
  u1[x, y, 0] == 0,
  u2[x, y, 0] == 0,
  D[u1[x, y, t], t] /. t -> 0 == 0,
  D[u2[x, y, t], t] /. t -> 0 == 0
};

(* Boundary conditions for  (electrodes) *)
BCs = {
   /. x -> xmin == 0,
   /. x -> xmax == 1000  (* Apply 1 kV across the structure *)
};

(* Fixed mechanical boundary at y = 0 *)
mechBCs = {
  u1[x, ymin, t] == 0,
  u2[x, ymin, t] == 0
```

```
};

(* PDE system *)
pdeSystem = {
  Eq,
  elasticEq[1],
  elasticEq[2]
};

(* Solve the coupled system *)
solution = NDSolve[
  Join[pdeSystem, initConds, BCs, mechBCs],
  {u1, u2, },
  {x, xmin, xmax}, {y, ymin, ymax}, {t, 0, tmax}
];
```

This code provides a basis for simulating how engineered piezoelectric dielectrics can produce dynamic internal strain fields, fundamental to the proposed metric engineering and propulsion mechanisms described in this paper.

References

[1] Max Born and Kun Huang, *Dynamical Theory of Crystal Lattices*, Oxford University Press, 1954. ISBN: 0-19-850369-5.

[2] Charles Kittel, *Introduction to Solid State Physics*, 8th ed., Wiley, 2005. ISBN: 978-0471415268.

[3] Warren P. Mason, *Piezoelectric Crystals and Their Application to Ultrasonics*, Van Nostrand, 1950.

[4] Fumio Narita and Zhenjin Wang, *Piezoelectric Materials, Composites, and Devices: Fundamentals, Mechanics, and Applications*, Academic Press, 2025. ISBN: 978-0323996679.

[5] Lev D. Landau and Evgeny M. Lifshitz, *The Classical Theory of Fields*, Course of Theoretical Physics Vol. 2, Butterworth–Heinemann, 1975. ISBN: 978-0750627687.

[6] Robert M. Wald, *General Relativity*, University of Chicago Press, 1984. ISBN: 978-0226870335.

[7] Sean M. Carroll, *Spacetime and Geometry: An Introduction to General Relativity*, Addison–Wesley, 2004. ISBN: 978-0805387326.

[8] Francis S. Galasso, *Advanced Fibers and Composites*, Macmillan, 1964.

[9] V.Z. Parton and B.A. Kudryavstev, *Electromagnetoelasticity: Piezoelectrics and Electrically Conductive Solids*, Nauka / Plenum Press, 1973.

[10] Thomas T. Brown, *The Biefeld–Brown Effect: Experimental Observations*, Private monograph / research report.