Bipolar Gravity

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1 Tests of General Relativity Theory

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} - \Lambda g_{\mu\nu}$$

Beauty test of equations is certainly passed in a theorist eye.

Clean tests are confined to solar system:

Exploration of **space-time geometry** (small test masses, clocks, electromagnetic radiation)

Issues difficult to test:

- **Does radiation gravitate** (generate a gravitational field)?
- Does matter attract or repel (**MAR**) antimatter?

These Questions cannot be answered by 'laboratory' tests.
Must have model of (early) universe, and see whether predictions match findings of cosmological observations.

2 Matter-Antimatter Repulsion, MAR

Motivation: Standard model of Cosmology leaves many **fundamental questions unanswered**.

- **Matter-Antimatter Asymmetry** (Baryogenesis)
  No compelling theory (Andrew Liddle)
- **Horizon problem** (why is CMB so isotropic: 10^{-4})
  Inflation theory, postulates scalar field (fantasy, Roger Penrose)
- **Flatness problem** (space is flat, experimental result, WMAP)
  Dark energy (what is it?) needed to obtain critical density
- **Accelerated Expansion** (derived from distances of supernovae Ia)
  no acceleration in Friedmann model, need dark energy again
- **Dark Matter problem** (unknown matter, manifest in galactic dynamics)
  WIMPS postulated (standard model requires **cold** dark matter)

New precision measurements often require new theoretical postulates

If **matter and antimatter repel** (**MAR**) each other gravitationally these problems would (conceivably) disappear.

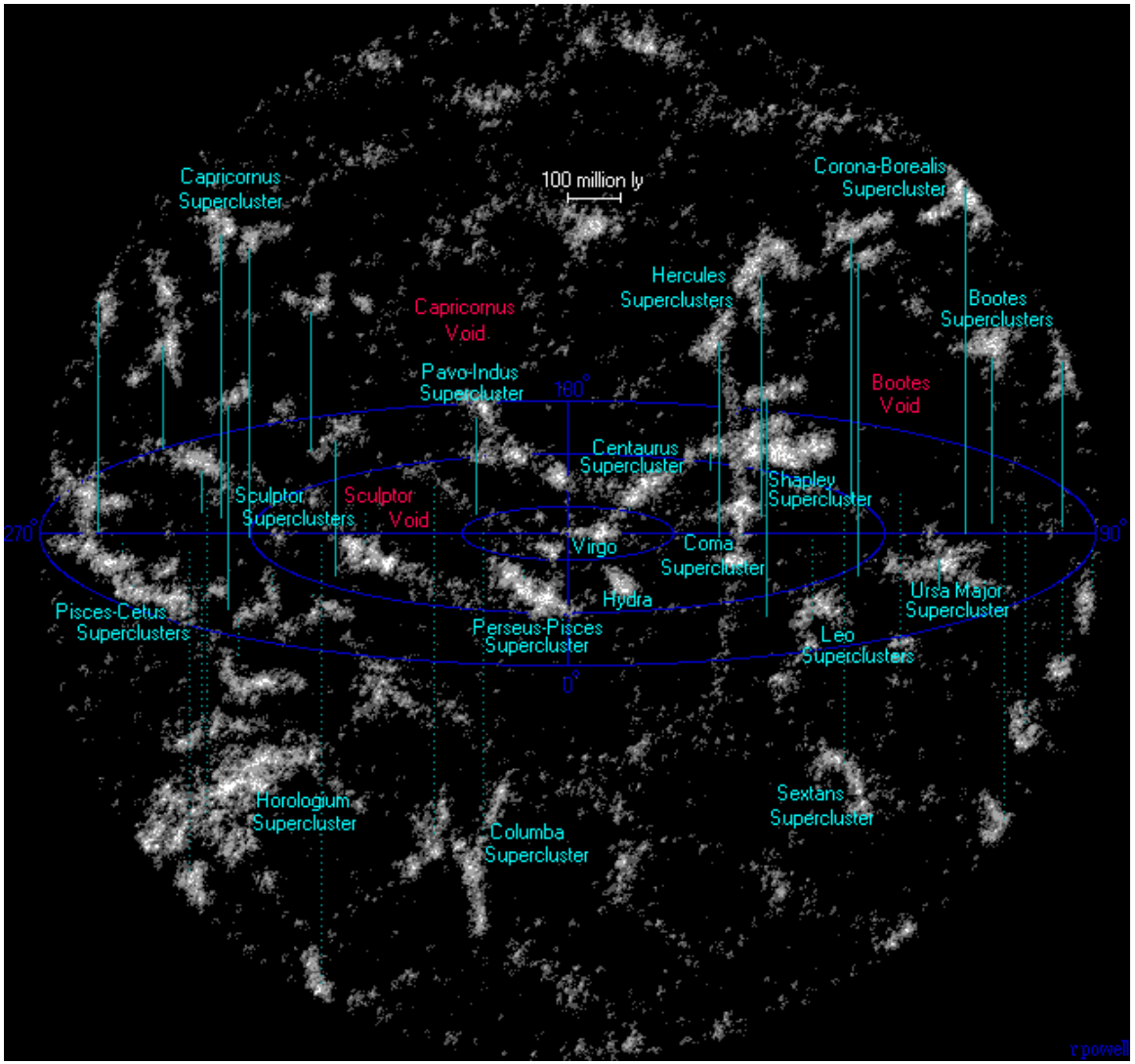
General Relativity (GR) is an **attraction-only** theory. Thus, MAR would require a modification of GR.

3 Universe in MAR-Interpretation

- Current Universe consists of **islands of Matter and Antimatter** of the **size** of (super) clusters of galaxies. They **avoid** each other due to repulsion. Thus, **no annihilation radiation** is expected.

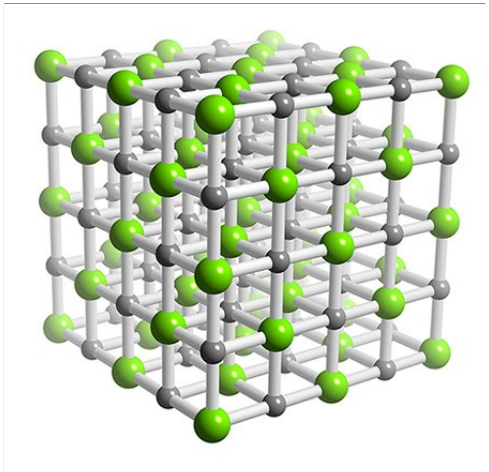
- **Galaxy surveys** give no contradiction, 90% of volume filled by **voids**. In standard Cosmology: Why are galaxies so rare in voids (P.J.E. Peebles)?

- **Radiation** consists of particles that are **their own antiparticles**. Thus, it does **not gravitate**, but experiences **geometry of space-time**.



R. Powell

4 MAR lattice-model for the universe



Most regular arrangement is a crystal (like NaCl) with matter- (Na) and antimatter- (Cl) cells of equal mass.

Within each cell the rest of the lattice generates a **confinement potential V(r)** which can be expanded as Taylor series about center of cell:

$$V(r) = M_1 G \rho R^2 + M_3 G \rho r^2 + \cdots$$

r = distance from center of cell, R = distance to center of next cell
ρ = average density of the universe, G = gravitation constant
M_1 = Madelung constant, 1.748 (for NaCl-lattice)
M_3 = analogous sum (-3rd power and direction cosines), also **of order one**

The second term is an **attractive quadratic potential**, **independent** of the lattice constant R. Towards the cell borders it provides **forces of comparable size** to the ones generated by the mass within the cell.

5 Pressure Considerations

A half space exerts a force on the cell mass which can be expressed as a pressure by division through the area of the corresponding cell face:

$$\frac{p}{\rho R^2} = M_2 G \rho, \qquad M_2 = \sum_{j=cells}^{\cos(j)>0} \sigma_j \cos(j) \left(\frac{R}{r_j}\right)^2 \quad , \ \sigma_j = \pm 1$$

In acceleration equation, M_2 half-space Madelung-type 'constant'

MAR

- Pressure is **positive**.
  Expansion **accelerates**.

- M_2 ($\sigma_j = \pm 1$) converges also for **infinite particle horizon**

- Condition on density is equality of matter and antimatter, **fulfilled by symmetry**.

- **No dark energy** needed

All-attractive case

- Pressure is **negative**.
  Expansion **slows down**.

- M_2 ($\sigma_j = -1$), to converge, need **finite particle horizon**.

- Expansion of Universe must be **balanced** such as to keep the particle horizon finite.
  -> **critical density condition**.

- Need **dark energy** for a flat universe

6 Radiation Pressure

- The **only force** that occurs in General Relativity is **gravitation**. It can be viewed as an **always negative gravitation pressure**. Expansion work done by **radiation pressure** is overcompensated by the **gravitation pressure** of the radiation energy. This yields an overall **negative** pressure.

Assuming **MAR**:

- No negative gravitation pressure from radiation

- **Positive radiation pressure** remains (e.g. from Cosmic Microwave Background radiation).

- Additional source of **accelerated expansion** of the Universe.

- In early universe, before matter-antimatter separation, radiation pressure governs expansion together with pressures (positive and negative) originating in other fundamental forces.

- These pressures show **no divergence problems** with an infinite particle horizon.

7 Theory: Geometry Generating Function

- Static argumentation, restricted to 3-d space

- Introduce **geometry generating** function **G(r)** for a mass at origin

- Metric tensor = unit tensor + symmetric product gradG * gradG

- For a mass point: **$G(r) = \pm 2s(r/s-1)^{1/2}$**, **both** signs possible

  $s = m2G/c^2$, Schwarzschild radius

- This yields the familiar **Schwarzschild** metric, **same for either sign**

- Possibility for a **sign change** (G or gradG) is **lost** on the level of geometry

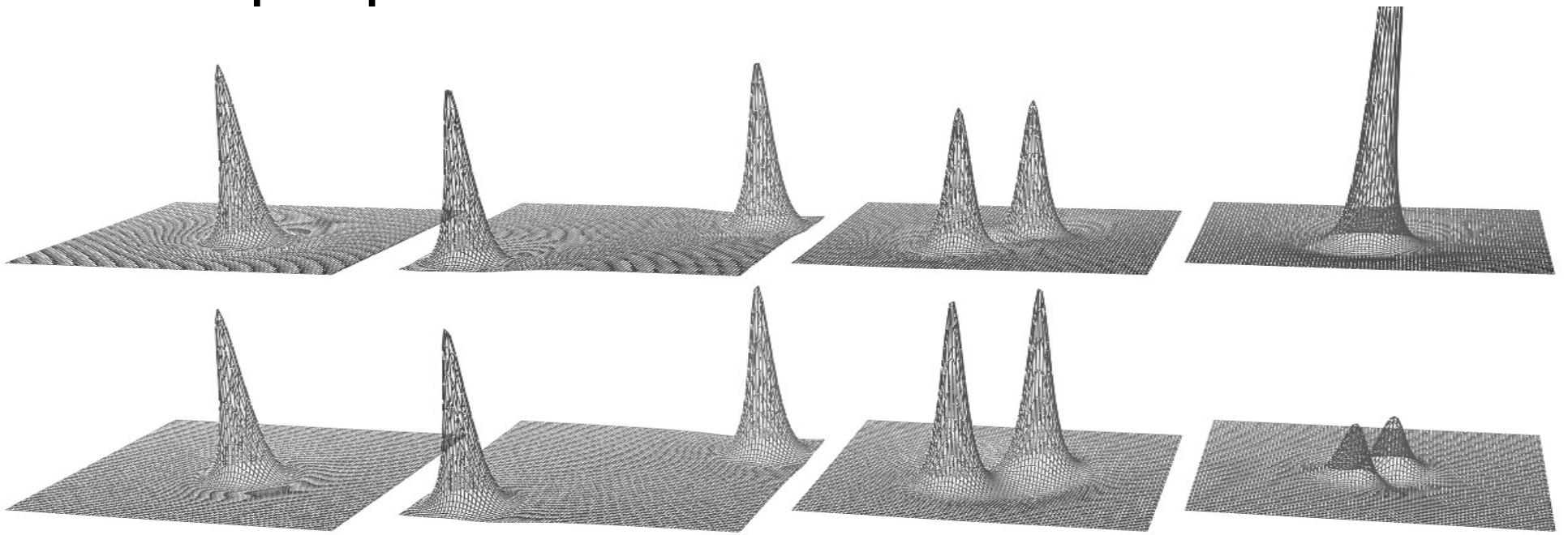
Question: **Theory possible with scalar field (G) or vector field ?**

Infinitesimal:

$$dG(r) = \pm\sqrt{ds(r')}\,2\sqrt{|r-r'|-ds(r')} \Rightarrow \pm\sqrt{ds(r')}\,2\sqrt{|r-r'|}$$

(Stieltjes?)

8 Superposition modes in 2 dimensions

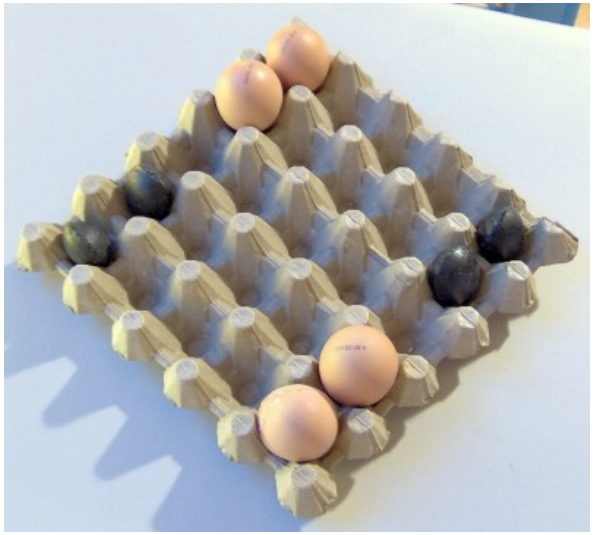


Curvature for 'masses'
identical for both signs

Top: superposition of two 'masses' of **same sign**
Bottom: annihilation of two 'masses' of **opposite sign**

Egg Carton

An illustration of a lattice-model of a 2-dimensional Universe embedded in three dimensions



Up: **matter** regions

Down: **antimatter** regions

Both regions have **identical curvature**

9 Development of MAR-Universe: Scenario

- **Perturbations** in matter-antimatter balance (difference-density modes) are **promoted** by matter-antimatter repulsion.

- They can have **constant density** and are, thus, **not suppressed** by radiation pressure (Jeans - Lifshitz).

- Baryogenesis: **Baryon-** and **Antibaryon-** rich regions develop in islands.

- On cooling, annihilation of still mixed pairs yields **low baryon-photon ratio**. Annihilation continues along island interfaces till photon decoupling.

- Development of universe as **continuing Phase Separation**

- Islands **grow by coagulation** (instability modes in lattice model).

- **Dark matter** (antimatter) can assemble in corresponding islands when free streaming ceases with cooling. Thus, **Neutrinos are possible candidates**.

- Expansion of universe is **accelerated**, caused by MAR and radiation pressure, which decrease with expansion.

Bottom Lines

- **MAR**, Matter-Antimatter Repulsion (assumed). [see slides 1, 2]
  Needs modification of GR.

- **Radiation does not gravitate** (generate gravitational field). [3]
  Modification of GR

- Baryogenesis: consists of **Baryon-Antibaryon separation** in islands. [9]

- Horizon problem: **No finite particle horizon** required, converging sum [5]

- Flatness problem: **No critical density** necessary, instead:
  Matter-Antimatter symmetry replaces corresponding constraint. [5]

- **Accelerated expansion**: caused by MAR and radiation pressure (CMB) [5, 6, 9]

- Homogeneous pressures of **radiation** and **remaining fundamental forces**
  govern expansion of early universe (slow bang). [6]

- **Neutrinos** are possible **dark matter** candidates. [9]

- Hope for a Gravitation Theory on the level of a **vector field** or possibly a
  scalar field (geometry-generating function), may be **quantizable**. [7, 8]