

Hey Grok 4, can you find any mathematical errors in Jean-Pierre Petit's Janus Cosmological Model ?

The Janus Cosmological Model (JCM), proposed by Jean-Pierre Petit, is a bimetric theory positing a universe with two interacting metrics: one for positive masses (ordinary matter) and one for negative masses (hypothetical matter with negative energy). Positive masses attract each other, negative masses attract each other, and opposite masses repel, aiming to explain phenomena like galactic rotation curves, cosmic acceleration, and the absence of primordial antimatter without invoking dark matter or dark energy in the conventional sense. The model derives from extensions of general relativity, incorporating ideas from Andrei Sakharov's twin-universe concept and bigravity theories.

After reviewing available sources, including papers, rebuttals, forums, and critiques, **no unchallenged mathematical errors in the current formulation of the JCM were identified.** However, **several criticisms have been raised, primarily by physicist Thibault Damour,** along with scattered points in online discussions. These focus on potential inconsistencies, some of which stem from earlier versions of the model that have since been corrected or clarified. Below, I summarize the key points, drawing from Damour's analyses (2019 and 2022) and the authors' rebuttals, as well as other sources.

Main Criticisms and Potential Mathematical Issues

Inconsistency in Force Interpretation for Negative Masses:

Criticism:

Damour argues that the model's heuristic force laws (e.g., negative masses attracting each other) are mathematically inconsistent in a relativistic framework. He claims a negative-mass test particle would be repelled (not attracted) by another negative mass, based on applying standard general relativity reasoning or his own bigravity models to Petit's equations. This could imply a failure to provide a coherent relativistic description of interactions.

Relevant Equations:

The issue ties to the bimetric field equations in the Newtonian limit:

$$R_{\mu\nu}^{(+)} - \frac{1}{2} R^{(+)} g_{\mu\nu}^{(+)} = \chi \left[T_{\mu\nu}^{(+)} + \hat{T}_{\mu\nu}^{(-)} \right]$$

$$R_{\mu\nu}^{(-)} - \frac{1}{2} R^{(-)} g_{\mu\nu}^{(-)} = -\chi \left[T_{\mu\nu}^{(-)} + \hat{T}_{\mu\nu}^{(+)} \right]$$

Here, $R_{\mu\nu}^{(\pm)}$ are Ricci tensors for positive/negative metrics, $T_{\mu\nu}^{(\pm)}$ are energy-momentum tensors, $\hat{T}_{\mu\nu}^{(\pm)}$ are interaction tensors, and $8\pi G/c^4$ (Einstein constant, with a sign flip for the negative sector). **Damour suggests the sign flip leads to repulsion, not attraction, for negative masses.**

Rebuttal and Resolution:

Petit et al. counter that Damour misapplies assumptions from his own models (e.g., using the same Einstein constant without the sign change). They derive the equations from an action principle (shown in their rebuttal appendix) and cite numerical simulations confirming the intended attractions/repulsions. To derive the force laws: Start with the geodesic equation for a test particle in the positive metric influenced by negative mass; vary the action

$$S = \int \sqrt{g_{\mu\nu} dx^\mu dx^\nu}$$

incorporating the negative-sector metric, yielding acceleration consistent with repulsion from positive mass but attraction among negatives. No error is evident post-rebuttal, as the math holds in the Newtonian approximation used for observables.7f7d2c
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Violation of Bianchi Identities:

Criticism: **Damour claims the model violates Bianchi** identities (requiring zero covariant divergence of the energy-momentum tensor's right-hand side for consistency with geometry). He references a 2014 version of the equations where interaction tensors $\hat{T}_{\mu\nu}^{(\pm)}$ were mistakenly equated to matter tensors $T_{\mu\nu}^{(\pm)}$ without hats, leading to inconsistencies in non-steady-state scenarios (e.g., during cosmic expansion).

NDT : Gork4 comprend que ce n'est pas une « faute de calcul » mais une « faute de frappe » sur laquelle s'est basée toute l'étude de Damour.

Relevant Equations:

The erroneous 2014 system (admitted typo):

$$R_{\mu\nu}^{(+)} - \frac{1}{2} R^{(+)} g_{\mu\nu}^{(+)} = \chi \left[T_{\mu\nu}^{(+)} + T_{\mu\nu}^{(-)} \right]$$

$$R_{\mu\nu}^{(-)} - \frac{1}{2} R^{(-)} g_{\mu\nu}^{(-)} = -\chi \left[T_{\mu\nu}^{(-)} + T_{\mu\nu}^{(+)} \right]$$

Covariant divergence:

$$\nabla^\mu \left[T_{\mu\nu}^{(+)} + T_{\mu\nu}^{(-)} \right] \neq 0$$

in unsteady conditions, violating

$$\nabla^\mu G_{\mu\nu} = 0$$

Einstein tensor property).

Rebuttal and Resolution:

Petit et al. acknowledge the 2014 typo (missing hats on interaction terms) but show the corrected system satisfies Bianchi identities in the Newtonian limit (detailed in their 2019 Progress in Physics paper).

To verify :

Compute the divergence using interaction tensors as

$$\hat{T}_{\mu\nu}^{(-)} = \sqrt{\frac{-g^{(-)}}{-g^{(+)}}} T_{\mu\nu}^{(-)}$$

with inverted pressure terms; in homogeneous/isotropic cosmology, the divergence vanishes, ensuring consistency. Damour later conceded this in 2022 after reading clarifications. [4482ec5ebe86 jp-petit.org](https://arxiv.org/abs/2204.04482)

Lack of Derivation from an Action Principle:**Criticism:**

Damour implies the equations aren't derived from a variational principle (action), undermining their theoretical foundation, as robust gravity theories (e.g., general relativity) stem from actions like the Einstein-Hilbert action.

Relevant Equations: Standard action for bigravity:

$$S = \int \left(\sqrt{-g^{(+)}} R^{(+)} + \sqrt{-g^{(-)}} R^{(-)} + L_{int} \right) d^4x$$

where L_{int} handles interactions.

Rebuttal and Resolution:

Petit et al. provide a derivation in their rebuttal appendix:

Vary an action with hypervolumes based on dual metrics, leading to the field equations.
To arrive at it: Minimize

$$S = \int \left(m_+ c \sqrt{g_{\mu\nu}^{(+)} dx^\mu dx^\nu} + m_{-+} c \sqrt{g_{\mu\nu}^{(-)} g_{\mu\nu}^{(+)} dx^\mu dx^\nu} \right)$$

incorporating negative masses; this yields consistent equations without paradox.364db8
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Other Scattered Criticisms:

Physical Incoherence (e.g., Neutron Stars): Damour notes issues with interaction tensors for dense objects like neutron stars, where inverted pressure might not hold.

Rebuttal:

Irrelevant, as simulations show no such objects in the negative sector.000aeb jp-petit.org

Graph/Presentation Errors:

In a forum discussion, a pressure-ratio graph for subcritical objects had a mathematical error (wrong critical radius formula);

Corrected to

but this was a presentation issue, not core model error.3965fc

$$\tilde{R} = \sqrt{\frac{3c^2}{8\pi G\rho}}$$

Negative Mass Violations:

Some sources note negative mass could violate energy conditions (e.g., weak energy condition), leading to instabilities like runaway motion.

The JCM avoids this via mutual repulsion/attraction rules, but no math error is proven.eb20a768ef5b

Two Speeds of Light:

Unconventional and potentially inconsistent with special relativity, **but the paper frames it as emergent from dual metrics, without explicit error.**^{b7c86d}

Overall Assessment

The JCM has faced scrutiny, particularly from Damour, but Petit's team has rebutted each point with corrections (e.g., 2014 typo), derivations, and simulations.

Sources like Petit's papers claim mathematical and physical coherence, with observational fits (e.g., supernova data). No consensus on errors exists in mainstream physics, as the model is fringe and not widely peer-reviewed beyond specific journals. If errors exist, they may lie in untested relativistic regimes beyond the Newtonian approximation, but none were substantiated in the reviewed materials. For deeper verification, consulting the full papers (e.g., via arXiv or Petit's site) is recommended.