A French academician who doesn't understand the Janus model

2023

The Janus cosmological model represents a profound change in the geometric representation of the universe. After Einstein it was described it as a "four-dimensional hypersurface". The Janus model extends this geometric vision by endowing this hypersurface with an "underside" where particles of negative energy and mass are located. Mathematically, this implies a "bimetric" description, where the two entities interact, hence the term "bigravity".

As it happens, the first person to propose a similar project was French academician Thibault Damour, in 2002.[1].

Thibault Damour, academician.

The articles, cited in the footnotes, are accompanied by an address from which they can be downloaded.

Damour and Kogan attempt to construct a “two-branes” theory, involving a spectrum of gravitons endowed with masses, but this 40-page paper ends up in a fishtail. In passing, they show that such bigravity must obey a system of two coupled field equations:

$$2\,M_L^2\left(R_{\mu\nu}(g^L)-\frac{1}{2}\,g^L_{\mu\nu}\,R(g^L)\right)+\Lambda_L\,g^L_{\mu\nu}=t^L_{\mu\nu}+T^L_{\mu\nu}\,,$$

$$2\,M_R^2\left(R_{\mu\nu}(g^R)-\frac{1}{2}\,g^R_{\mu\nu}\,R(g^R)\right)+\Lambda_R\,g^R_{\mu\nu}=t^R_{\mu\nu}+T^R_{\mu\nu}\,.$$

[1] T.Damour & I.I.Kogan : Effective Lagrangian and Universality classes of Nonlinear Bigravity. Phys. Rev. D **66** (2002). http://www.jp-petit.org/papers/cosmo/2002-Damour-Kogan-bigravity.pdf

Six years later, German Sabine Hossenfelder[2] (who has now become a science blogger) takes a more precise approach. This time, it's a question of conferring an identity on the inhabitants of this second fold of universe, in the form of negative masses. In 1957, cosmologist Hermann Bondi attempted to introduce these masses into Albert Einstein's model[3]. But the so-called runaway phenomenon (see the album) brings to light physical contradictions so that the model contradicts fundamental principles of physics, such as the action-reaction principle and equivalence. Sabine Hossenfelder also constructs her system of two coupled field equations:

$$
\begin{aligned}
{}^{(g)}R_{\kappa\nu} - \frac{1}{2} g_{\kappa\nu}\,{}^{(g)}R &= T_{\kappa\nu} - \underline{V}\sqrt{\frac{\underline{h}}{g}}\, a_{\nu}^{\underline{\nu}}\, a_{\kappa}^{\underline{\kappa}}\, \underline{T}_{\underline{\nu}\underline{\kappa}} \\
{}^{(\underline{h})}R_{\underline{\nu}\underline{\kappa}} - \frac{1}{2} h_{\underline{\nu}\underline{\kappa}}\,{}^{(\underline{h})}R &= \underline{T}_{\underline{\nu}\underline{\kappa}} - W\sqrt{\frac{g}{\underline{h}}}\, a_{\underline{\kappa}}^{\kappa}\, a_{\underline{\nu}}^{\nu}\, T_{\kappa\nu}
\end{aligned}
$$

But she can't get rid of the discrepancy with physical principles. Believing that this is inexorably linked to bigravity, she gives up..

In 2014 we published a first exact solution of our system of coupled field equations, physically and mathematically consistent, but which limits the solutions to a description of a homogeneous, unsteady isotropic universe.

$$
R_{\mu\nu}^{(+)} - \frac{1}{2} R^{(+)} g_{\mu\nu}^{(+)} = \chi \left[T_{\mu\nu}^{(+)} + \left(\frac{a^{(-)}}{a^{(+)}} \right)^3 T_{\mu\nu}^{(-)} \right]
$$

$$
R_{\mu\nu}^{(-)} - \frac{1}{2} R^{(-)} g_{\mu\nu}^{(-)} = -\chi \left[\left(\frac{a^{(+)}}{a^{(-)}} \right)^3 T_{\mu\nu}^{(+)} + T_{\mu\nu}^{(-)} \right]
$$

Mathematical consistency translates into a generalized conservation of energy. The exact solution derived from the equations shows that the "dark energy" driving the acceleration of cosmic expansion is none other than that of negative mass, which is in the majority.

In 2018 Gilles d'Agostini exploited this exact solution and showed that the model, christened Janus, perfectly accounts for the data from type Ia supernovae, which earned S.Perlmutter , A.G. Riess and Schmidt the Nobel Prize for showing that the expansion of the universe, far from slowing down, was actually accelerating. Here's how G.D'Agostini's curve fits perfectly with the observational data:

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[2] S. Hossenfelder : A bimetric Theory with Exchange symmetry Phys. Rev. D78, 044015, 2008 and arXiv : 0807.2838v1 (gr-qc)17 july 2008. http://www.jp-petit.org/papers/cosmo/2008-Hossenfelder.pdf

[3] H. Bondi: Negative mass in General Relativity : Negative mass in General Relativity. Rev. of Mod. Phys., Vol 29, N°3, july1957

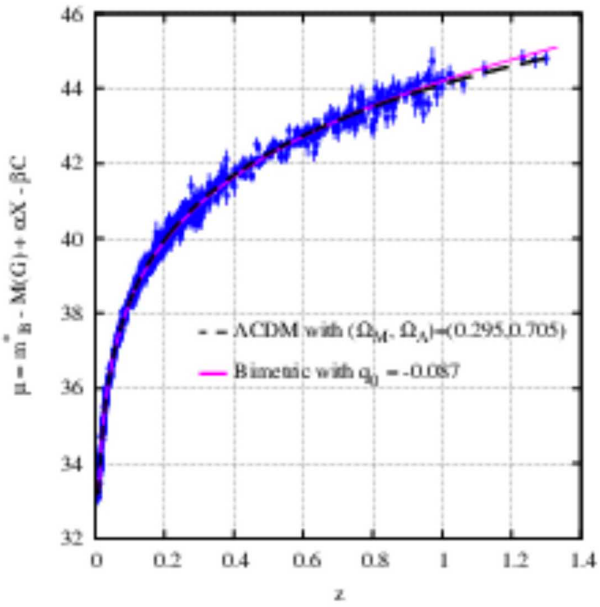

Figure 7: Hubble diagram of the combined sample and compraison with the 2 models (linear scale)

The mathematical consistency of the system of coupled field equations dictates that the terms of both members of the equations must have zero covariant derivatives. This applies to their first members, by construction. In physical terms, this translates into the satisfaction of conservation equations.

Einstein's equation provides only two types of solutions.

First, there are unsteady solutions under conditions of isotropy and homogeneity. Satisfaction of the condition translates into conservation of energy. We have seen that the same applies to the Janus equations. In the second article of 2014[4] the extension had been operated with two different light speeds.

The second set of solutions refers to stationarity (invariance by temporal translation), combined with assumptions of spatial symmetry. As in Einstein's model, the Newtonian approximation provides the $1/r^2$ law and the sign of the forces. The forces deduced from the Janus equations (see comic strip) are in line with the principles of action-reaction and equivalence. The mathematical consistency of the equations in vacuum poses no problem, since both second members are zero.

But in 2014, at the model development stage, it was not possible to determine the geometry inside the masses. Indeed, the equation translating the physical and mathematical coherence in this region of space simply translates into the fact that the forces of gravity

[4] J.P.Petit, G.D'Agostini : Cosmological Bimetric model with interacting positive and negative masses and two different speeds of light, in agreement with the observed acceleration of the Universe. Modern Physics LettersA, Vol.29 ; N° 34, **2014** ; Nov 10th
http://www.jp-petit.org/papers/cosmo/2014-ModPhysLettA.pdf

within the masses must be balanced by the forces of pressure. During 2018, we finally succeeded in this project and were in dialogue with a peer-reviewed journal to publish a first result, limited to the conditions of the Newtonian approximation, which represents 99% of astrophysical phenomena. The article[5] will be published in the early days of January 2019.

At the same time, French academician Thibault Damour, considered the country's foremost expert on cosmology, published an article entitled [6] « About the so-called Janus Cosmological Model" in his page on the website of the Institut des Hautes Études to which he belongs, the French equivalent of the Institute for Advanced Studies in Princeton, USA. He also sent me a registered letter with acknowledgement of receipt, announcing the publication of an article which, in his opinion, put an end to what he considered to be ramblings.

Flabbergasted, we immediately replied, telling him that we'd just solved the problem through an article, a copy of which we sent him, and proposing a meeting.

No reply.

Months and years go by without Mr Damour replying to any of our messages. In 2022, november 11, three years after Mr. Damour's article went on line, a letter, co-signed by fellow scientists who had themselves verified the accuracy of our calculations, was sent to him, asking for his reaction.

The reaction was immediate. On December 12, 2022, he published a second article on the IHES website, a veritable act of authority, entitled :

Physical and mathematical inconsistency of the Janus cosmological model.[7]

He then bases this new article on the fact that in the Janus model "negative masses attract each other, whereas it is well known that they repel each other". He thus demonstrates that he hasn't actually read our articles, and bases his argument on Herman Bondi's result from 1950. In the Einsteinian model, indeed, these negative masses repel each other. But in the Janus model, they attract. But there's none so deaf as those who don't want to understand.

It's easy to deduce the direction of the forces by constructing geodesics in a vacuum. The result is :

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[5] J.P.Petit, G. D'Agostini, N.Debergh : Physical and mathematical consistency of the Janus Cosmological Model (JCM). Progress in Physics 2019 Vol.15 issue 1. http://www.jp-petit.org/papers/cosmo/2019-Progress-in-Physics-1.pdf

[6] http://www.jp-petit.org/papers/cosmo/2019-Damour-IHES-eng.pdf

[7] http://www.jp-petit.org/papers/cosmo/2022-12-12-Damour-IHES.pdf

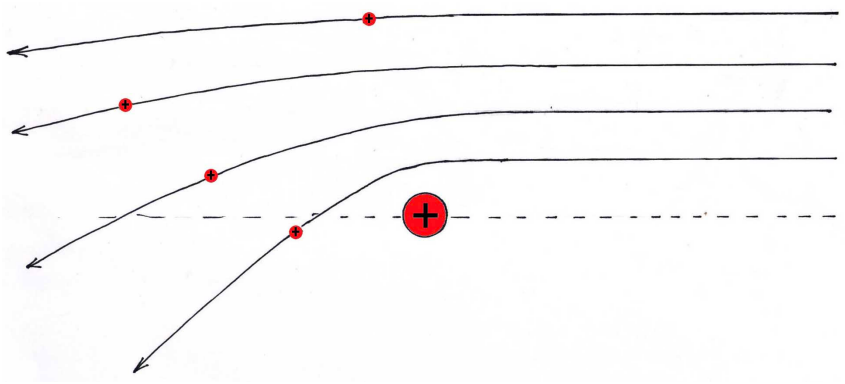

Fig.1 : Positive masses attract each other

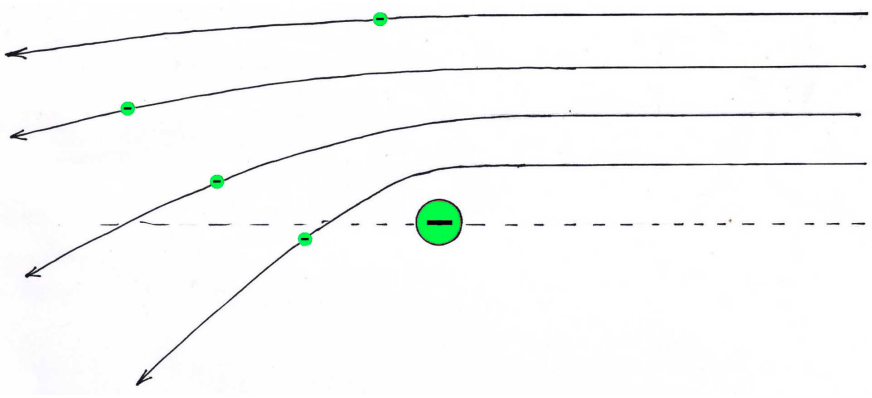

Fig.2 : Negative masses attract each other

This shows that in three years, Damour simply hasn't read the articles we've published. In particular, he has failed to grasp the importance of the minus sign in front of the second member of the second field equation, highlighted in red below, which re-establishes the principles of action-reaction and equivalence, and makes the unmanageable runway phenomenon disappear.

$$R^{(+)}{}_{\mu}^{\nu} - \frac{1}{2} R^{+} \delta_{\mu}^{\nu} = \chi \left[T^{(+)}{}_{\mu}^{\nu} + \sqrt{\frac{g^{-}}{g^{+}}} \, \hat{T}^{(-)}{}_{\mu}^{\nu} \right]$$

$$R^{(-)}{}_{\mu}^{\nu} - \frac{1}{2} R^{-} \delta_{\mu}^{\nu} = -\chi \left[\sqrt{\frac{g^{+}}{g^{-}}} \, \hat{T}^{(+)}{}_{\mu}^{\nu} + T^{(-)}{}_{\mu}^{\nu} \right]$$

On December 14, 2022, we immediately pointed out his error. [8].

[8] http://www.jp-petit.org/papers/cosmo/2022-12-14-to-Damour.pdf

He then abandons this criticism and replaces this second article with a third one [9], posted on December 18, 2022, still on his IHES page, and expands on the alleged impossibility of integrating the neutron star model.

But here again, this last criticism doesn't hold water.

There is no need to explain the form of the "interaction tensors":

$$\hat{T}^{(+)}{}_{\mu}^{\nu} \qquad\qquad \hat{T}^{(-)}{}_{\mu}^{\nu}$$

All we need to do is specify that their respective divergences must be zero. This is what Damour says in his 2002 article. But he doesn't go further. In fact, it is this condition of compatibility and coherence that dictates the form of these two tensors. At this point, we should remember that general relativity, which translates into cosmic geometry being based on Albert Einstein's field equation, is in fact based on only two types of solution:

- Unsteady solutions (invariance of the solution by time translation) with isotropy and homogeneity.

- Stationary solutions with invariance under the action of the SO(3) (spherical symmetry) and SO(2) (axisymmetry) groups.

For the moment, the axisymmetric, SO(2)-invariant stationary solution of Einstein's equation can be expressed by the Kerr exterior metric [10] (1963) (describing geometry in a vacuum, outside a field-creating mass). This solution should logically be completed by its complement, the solution expressed in the form of an internal metric. But this has never been produced. The Janus equations provide the joint exterior metrics, two-folds extensions of this Kerr exterior metric. As these solutions are derived from the equations without a second member, their mathematical consistency follows automatically. The system must therefore be physically and mathematically consistent in both configurations;

- Unsteady solutions (invariance of the solution by time translation) with isotropy and homogeneity.

- Stationary solutions with invariance under the action of SO(3) groups (spherical symmetry).

The question has been solved in the first case with our 2014,2015, 2018 papers. The compatibility equation then translates into the generalized conservation of energy:

$$E = \rho^{(+)}c^{(+)2}a^{(+)3} + \rho^{(-)}c^{(-)2}a^{(-)3} = Cst$$

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[9] http://www.jp-petit.org/papers/cosmo/2022-12-28-Damour-IHES.pdf

[10] R.Kerr : Gravitational field of a spinning mass as an example of algebraic special metrics. Physical Review Letters Vol. 11#5 1963 set. 1st. http://www.jp-petit.org/papers/cosmo/1963-Kerr.pdf

In the second case, as Damour agrees in the article posted on his page of the IHES website on December 28, 2022, these conditions are also fulfilled in the Newtonian approximation (low curvature, low velocities ahead of the speed of light).

This includes the geometric description of the region of space corresponding to the Great Repeller phenomenon, both inside and outside this object. The geodesics followed by positive-energy photons (which alone lend themselves to confrontation with observation) can be deduced from the pair of inner and outer Schwarzschild metrics generated by a negative-mass source.

This left us with the problem of describing the geometry inside a neutron star, which is based on this Newtonian approximation. Everything that could be done in this direction was fully described in Karl Schwarzschild's two papers of 1916. The first describes the geometry outside a mass.[11]

A month later, he published a paper describing the geometry inside the mass [12]. Thi paper was not available in English until 1999, so some scientists who claim to be experts in cosmology are unaware of its existence.

Three authors have given their names to the so-called TOV equation of state (Tolman [13]-Oppenheimer-Volkoff[14]) which is simply a reformulation of the 1916 solution in another coordinate system.

This can be reconciled as a solution of the Janus system, based on the fact that these neutron stars are automatically located (positive and negative masses are mutually exclusive) in a region where negative mass is practically absent, and the system is reduced to equation

$$R^{(+)\nu}_{\ \ \mu} - \frac{1}{2} R^{(+)} \delta^{\nu}_{\mu} = \chi \, T^{(+)\nu}_{\ \ \mu}$$

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[11] K.Schwarzschild : Über das Gravitationsfeld Messenpunktes nach der Einsteinschen Theorie. Sit. Deut. Akad. Wiss. 1916. English translation by S.Antoci and A.Loinger. On the gravitational field of a mass point according to Einstein theory. arXiv :physics/9912033v1 [physics.hist-ph] 16 dec 1999
http://www.jp-petit.org/papers/cosmo/1916-Schwarzschild-exterior-en.pdf

[12] K.Schwarzschild : Über das Gravitionalsfeld einer Kugel Aus incompressibler Flüssigkeit nach der Einsteinschen Theorie. Sitzung der phys. Math. Klasse v.23 märz 1916. On the gravitational field of a mass point according to Einstein theory. arXiv :physics/9912033v1
[physics.hist-ph] 16 dec 1999. http://www.jp-petit.org/papers/cosmo/1916-Schwarzschild-interior-en.pdf

[13] http://www.jp-petit.org/papers/cosmo/1939-Tolman.pdf

[14] http://www.jp-petit.org/papers/cosmo/1939-Oppenheimer-Volkoff.pdf

This equation is nothing but Einstein's equation, in mixed notations, which explains in particular why the Janus model satisfies all local relativistic data (perigee advance of planetary orbits, deviations of light rays by masses).

A technically more detailed description can be found in the reply to T.Damour, in French[15].

Conclusion :

The challenge introduced by the Janus model is obviously a major one. It involves adopting a geometrical extension of general relativity, replacing the Einstein equation with the system of two coupled field equations of the Janus model:

$$R^{(+)}{}_{\mu\upsilon} - \frac{1}{2} R^{(+)} g^{(+)}{}_{\mu\upsilon} = \chi \left[T^{(+)}{}_{\mu\upsilon} + \sqrt{\frac{g^{(-)}}{g^{(+)}}}\, \hat{T}^{(-)}{}_{\mu\upsilon} \right]$$

$$R^{(-)}{}_{\mu\upsilon} - \frac{1}{2} R^{(-)} g^{(-)}{}_{\mu\upsilon} = -\chi \left[T^{(-)}{}_{\mu\upsilon} + \sqrt{\frac{g^{(+)}}{g^{(-)}}}\, \hat{T}^{+}{}_{\mu\upsilon} \right]$$

On such an important issue, it is totally anomalous that the French academician Thibault Damour should have contented himself, in the form of an act of authority, with publishing on the website of the institute to which he belongs two articles entitled:

Physical and mathematical inconsistency of the Janus model

Instead of publishing this criticism in due form in a peer-reviewed journal, which would have been an ethical response. On the contrary, he refused any exchange, any debate, any legitimate expression of a scientific right of reply.

J.P.Petit 2023

[15] http://www.jp-petit.org/papers/cosmo/2023-Refutation-critiques-Damour.pdf