Isolated systems are asymptotically… flat

Posted on **July 28, 2014** by **Adam Day**

— Martin Reiris is Junior Scientist at the Max Planck Institute for Gravitational Physics (Golm-Germany) since 2009. He received the PHD in pure math in 2005 at SUNYSB, and held a Moore Instructor in Math at MIT from 2006 to 2009. His interests are mainly in geometry and the mathematical structure of general relativity

In the extraordinary manuscript *The Foundation of the Generalised Theory of Relativity*, printed in 1916 in *Annalen der Physics*, Einstein begins addressing what he calls an epistemological defect of classical mechanics, (as well as of special relativity), whose dignity he attributes to E Mach. He imagined two bodies, A and B, made of the same fluid material and sufficiently separated from each other that none of the properties of one could be attributed to the existence of the other. Observers at rest in one body, he continues, see the other body rotating at a constant angular velocity, yet these same observers measure a perfect round surface in one case and an ellipsoid of rotation in the other case. It is then asked: "Why is this difference between the two bodies?".

Necessarily, he claims, the answer cannot be found inside the system A+B only; it must lie in its exterior: the outer empty space. Now we know that what we omitted in the argumentation above and that caused the apparent disparity, was realising that the empty space obeys also physical laws. These laws, which treat the parts A and B of the system A + B + Exterior Empty Space on an equal footing, are the Einstein equations of general relativity. There is one solution of the vacuum Einstein equations having a distinctive relevance: The flat Minkowski space. The asymptotic of isolated systems in particular, like the ideal system A+B above, was since ever modelled with the Minkowski spacetime. When we imagine a neutron star revolving a black hole we are making this assumption automatically. Asymptotic flatness was, and still is, an indisputable premise of isolated systems. This automatism roots deeply in our thinking and is historically related to the disparity above.

But in principle there could exist other natural asymptotics; could that be? In our sequence of papers (1,2) published in CQG it was proved that, under rather basic assumptions, asymptotic flatness is indeed the only possibility. More technically, we require that the three-space outside the material sources of the isolated system has the topology of the Euclidean three-space with a ball removed, and, in addition, that the system is in strict stationary equilibrium in such region. Then it is deduced that the spacetime is asymptotically flat.

The article discusses the extents and limitations of this result, highlighting particularly on the minimality of the hypothesis. Reference is made to the work of Michael Anderson on the uniqueness of the Minkowski spacetime and which was greatly influential.

Besides its theoretical interest there was also a concrete physical motivation: what can general relativity say about the gravitational distortions observed on the asymptotic of galaxies and which are commonly ascribed to the presence of dark matter? It appears that general relativity can only agree on the existence of dark matter as an unavoidable conclusion of the observations.

Read the full articles in *Classical and Quantum Gravity*:
Stationary solutions and asymptotic flatness I
Martin Reiris
2014 Class. Quantum Grav. 31 155012

Stationary solutions and asymptotic flatness II
Martin Reiris
2014 Class. Quantum Grav. 31 155013

Publish your next paper in CQG for the chance to benefit from promotion on CQG+. CQG papers are selected for promotion based on the content of the referee reports. The papers you read about on CQG+ have been rated 'high quality' by your peers.

TELL YOUR FRIENDS ABOUT CQG+

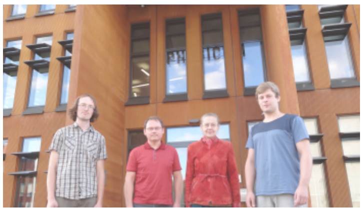
★ Like

One blogger likes this.

RELATED

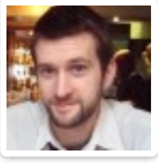
Book Reviews: 100 years after Einstein's stay in Prague edited by Jiří Bičák and Tomáš Ledvinka
In "Book reviews"

Gravity and scalar fields: live long and prosper?
In "IOPselect"



CQG+ Insight: Scalar-tensor cosmology: inflation and invariants
In "Author Insights"

This entry was posted in **Author Insights**, **IOPselect** and tagged **general relativity** by **Adam Day**. Bookmark the **permalink [https://cqgplus.com/2014/07/28/isolated-systems-are-asymptotically-flat/]** .



About Adam Day

Adam Day is the former publisher of Classical and Quantum Gravity. His background is mostly in publishing, where he thoroughly enjoyed working with the gravitational physics community. He now works as a Data Scientist for SAGE Publishing.

View all posts by Adam Day →