WHY SPACETIME IS NOT A HIDDEN CAUSE: A REALIST STORY

"Spacetime acts on matter telling it how to move" (Cf Wheeler)

How does – how *could* – spacetime do anything like that?

A common objection against realism runs like this: if spacetime is a real entity for General Relativity (GR) then surely the acting and the telling must be a causing - a *hidden* causing. But, equally surely, spacetime is the wrong kind of thing to *make* matter move. That's bad physics and bad metaphysics. But if spacetime causes nothing, it explains nothing either. So weed it out of the ontology of GR and settle for a codification. [This is widely & recently supported - DiSalle 1994, 1995. Brown 2005, pp. 24-5, Brown and Pooley 2006, Torretti 2007 p. 3n]

I reply that realism doesn't need and can't admit spacetime as causing matter to move. Spacetime is not a hidden cause because not a cause. Yet spacetime explains what matter does under pure gravitation.

I assume that spacetime is real and reply within that assumption. Nevertheless, objection and reply concern ontological issues.

I take GR as a local theory. If spacetime is a cause, it is an immediate one.

Galileo rejected the question what causes a flying arrow to keep flying? The useful question asks why it ever stops. There is no cause of rest or uniform motion. I call rest-or-uniform-motion a G-trajectory. A G-trajectory particle only has to *endure* (its worldline to *extend*) to occupy the trajectory. Maybe that's due to an immanent cause but (i) space (spacetime) is not that cause (ii) no immanent cause explains the structure of the G-trajectory. It is not a causal *trajectory*; it has zero acceleration.

In neo-Newtonian spacetime the G-trajectory is straight. Straights map directly to and from rest-or-uniform motion relative to some inertial frame for space and time. The same holds for Minkowski spacetime. The external-cause-free status of G-trajectories carries over to the relevant theories. It underwrites the 1st law.

There are G-trajectories in GR spacetime. In general, geodesics of spacetime do not translate into straight paths and constant speeds for freely chosen frames of reference either for Minkowski or pseudo-Riemannian spacetimes. They do not match the 1st law in these frames and a gravitational force, a cause, is postulated to explain their motion. But the criteria for the absence of non-external cause (spacetime as a cause) remain. Free fall particles are rest particles in

suitable frames and cause free – the particles merely endure, their worldlines merely extend. Spacetime does not cause this.

The explanatory role of spacetime in the behaviour of freely falling matter is 2-fold. It explains (familiarly enough) how the apparent gravitational dynamics of free-fall particles in general frames of reference vanishes into the mere kinematics of geodesics in flat or curved spacetimes. It explains also by citing *identities* in various ways. E.g. the deviation of geodesics is not *caused* by spacetime curvature: it *is* spacetime curvature. A bit less sketchily, suppose the trajectory of a cloud of test particles through flat spacetime projects it into a region of curved spacetime. There may be immanent causes for the persistence of the particles: they would explain how the cloud gets there. Nothing in this implicates spacetime causally. The flatness of the region of spacetime does not cause the curvature of the neighbouring region which the cloud traverses. The change in shape of the cloud, the deviation of its point-parts, *is* the deviation of geodesic worldlines and not caused by it.

So far in this story, matter is idealised as (more or less) particulate. But even test bodies have any spacelike cross-section intersected by more than one timelike geodesic and these deviate in curved spacetime. This clearly alters the causal story within any such body since elastic forces resist the deviation of small parts: internal stresses, distortions, will begin in the body. The causal story is exhausted in (i) the electromagnetic forces engaged in resisting the distortions and (ii) in the immanent causes of test body endurance. As before, spacetime explains the deviation of geodesics that change the forces, but it does not cause them.

Spacetime explains why the G-4-trajectory is such that *nothing needs a cause to extend along it*. At each point, its space-like acceleration vector is zero. The spacetime story is about the cause-free status *of the trajectory*. An occupying point is irrelevant save as an illustrative fiction. The orbit of Venus is calculated treating (among other approximations) the planet as a point. The observed advance of the planet’s perihelion, famously, is very close to the predicted one. In this, no one considers the theoretical stresses within the planet, induced as described, nor the unobserved imperfections in its geodesical trajectory. Such illustrations can serve to *trace* the structure of spacetime, may ignore the dynamics within the planetary body. Spacetime structure is not hidden (not concealed, obscured, not too small, not too fine) and easily revealed, even though not an object of direct observation.

An objection (Brown, Brown and Pooley): the authors take spacetime explanation as necessarily causal. They construe

test bodies as following “*grooves*” or “*gutters*” in spacetime along which spacetime “nudges” them. (E.g. Brown p24, p161 for “nudge”) Two matters are of interest. (i) The objection presupposes that test bodies, un-nudged, would be doing something *else* if not caused to roll (?) along these grooves. (ii) This envisages the *something else* as a state without external cause. But this admits that there is *some* cause-free state.

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