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THE MANY FACES OF GRAVITATION IN GENERAL RELATIVITY

Abstract: In consequence of the general covariance of Einstein's equations, their solutions are determined up to a diffeomorphism. Some authors claim that this implies arbitrariness of empirical predictions of general relativity. The others maintain that there is no real difference between diffeomorphic models. Both opinions seem one-sided. In fact, if the predictions are expressed in measurable quantities, no arbitrariness results. Contrary opinions result from errors in interpretation. This means that arbitrariness, if any, appears only on some sub-empirical level. On the other hand, it seems that the picture of phenomena resulting from the indifference thesis is incomplete. What is more, the advocates of that thesis often hold views inconsistent with it. In particular, they assume that the spacetime which represents the gravitational field around a spherically symmetric star is time-reflection symmetric, although this feature depends on the choice of the time coordinate. They also maintain that, in such a field, stationary physical clocks go slower the closer to its source they are, although, from their own point of view, comparison of distant clocks is meaningless in the framework of GR.

The indifference thesis is specific for the orthodox Einstein-Minkowski geometrical interpretation of relativity. In the alternative Lorentz dynamical interpretation it is assumed that gravitation affects not so much spacetime, but rather physical measuring rods and clocks. Its influence of them is an universal force in Reichenbach's sense. Another such force is the influence of the ether drift on matter moving relative to the ether. Both effects combine in GR spacetimes, where the Einstein equivalence principle holds, which is a generalization of the special principle of relativity. However, the precise way in which they do this is still unknown. It can be investigated by constructing ether-based model of solutions of the Einstein equations.

The Schwarzschild solution is of special interest in this respect. The way it can be derived depends on the assumption specifying the way gravitation works. It is natural to assume a flat background spatial metric. One model, which may be called ”hydrodynamical”, reduces gravitation to the flow of the ether toward the source with a velocity strictly equal to the Newtonian escape velocity. This results in the Schwarzschild metric in the Painlevé-Gullstrand coordinates. Another model, let it be called ”optodynamical”, reduces gravitation to some non-uniformity and anisotropy of the ether as the carrier of fundamental interactions. In it, the metric is derived in standard Schwarzschild coordinates. Whereas the first derivation is consistent with the ”black hole” picture of the Schwarzschild field, the second suggests the outdated ”frozen star” picture. Intermediate models are also possible. The latter seem the most appropriate for cosmological applications. However, the right procedure of constructing them is still to be found.