General Relativity by another name? A look at Teleparallel Gravity.

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Abstract

I examine the teleparallel theory of gravity (TPG). In this theory, the Levi-Civita connection of general relativity (GR), which has curvature but no torsion, is replaced with a Weitzenböck connection, with torsion but no curvature. Certain forms of the theory reproduce the empirical consequences of GR exactly. However, TPG's structure and equations at least superficially resemble those of electromagnetism far more closely than those of GR. As a result, many proponents of TPG claim that it restores to gravity its status as a force, rather than a manifestation of spacetime geometry.

This naturally raises two interconnected questions. First, do TPG and GR together constitute a case of empirical underdetermination, and if so, what kind? Second, is it correct that the theory is best interpreted as implying that gravity is a force? The answer to the first question depends on the second; one way in which we might establish genuine empirical underdetermination is by establishing that TPG and GR have divergent ontological commitments.

A look at the formal structure of TPG rapidly narrows the space of possible answers to the first question; TPG is rendered empirically indistinguishable from

GR by means of a single equation relating the Wietzenböck connection to the levi-Civita connection. This acts as a translation dictionary between the laws of teleparallel gravity and those of general relativity. As such, at the formal level, TPG is best seen as a reformulation of GR, rather than as a separate theory. Given this, any underdetermination must be of a particular kind, first highlighted in the literature by Roger Jones. In cases of what Oliver Pooley calls *Jones underdetermination*, a single theory possesses two alternative formulations, each of which lead to different ontological commitments.

Were it the case that TPG casts gravity as a force, then we might appear to have an unequivocal case of *Jones underdetermination*. I argue that this is not the case. Examination of the notion of an inertial frame within TPG shows the claim that gravity is a force to be deeply confused. Moreover, a gauge freedom on the part of entities that appear mathematically fundamental in TPG leads us back to an interpretation in which the metric field is ontologically fundamental. TPG is a great deal more geometrical, and a great deal less divergent from GR in its ontological commitments, than it at first appears.

Nonetheless, the fact that we can write GR in teleparallel language is interesting and informative. A study of teleparallel theory helps to clarify different notions of important geometrical notions like curvature, and is therefore helpful for understanding the sense in which GR is 'fundamentally' a theory about spacetime geometry. Far from robbing gravity of its geometrical significance, teleparallel theory helps to emphasise the deep connection between gravity and spacetime.