Philosophy of Space and Time: Week 2

Newtonian Spacetime Structure

> Newton's theory of absolute space and time, together with his Laws of Motion and the postulate that all forces are impulse forces due to collisions, commit him to the existence of experimentally undeterminable physical facts. This should give us pause. Is there any way to somehow purge these unobservable absolute velocities from Newton's theory yet keep all of its explanatory power? (Maudlin pp. 52-53)
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> We would prefer to somehow eliminate the absolute motions but retain the absolute rotations, which seems to be a contradiction. As it turns out, the trick can be done. But we need to radically revise our approach to space and time. (Maudlin p. 54)

Recap

- The globes: sometimes there is tension in the cord and the globes will fly apart if the cord is cut; sometimes there is no tension, and they will not do so.
- Newton wants to explain this difference by introducing absolute space—the globes in the latter case are rotating with respect to absolute space.
- The relationist provides no good account of the globes (and the Leibniz-Clarke correspondence ended (on Leibniz's death) before Leibniz could address it).
- Leibniz complained that Newtonian absolute space led to "distinctions without a difference"—for example, the statics or kinematically-shifted worlds, both of which are observationally (and relationally) equivalent to the actual world.
- Ideally, we want to introduce enough spacetime structure for there to be absolute *rotations* and *accelerations* (and thereby to account for the bucket and globes), but not *too much* structure—which is what leads to the shift scenarios in Newtonian mechanics set in Newton's absolute space.

- Today, we will see how to excise the surplus structure which leads to the (otherwise) physically distinct but observationally equivalent shift scenarios (and which makes meaningful notions such as absolute velocity).
- Doing so will require us to adopt a modern, *spacetime* perspective.

Newtonian Spacetime

Spacetime diagrams:

- Time slices
- Spacetime points (plot through time)
- Particle...
  - ...stationary with respect to the persisting points of absolute space.
  - ...moving uniformly with respect to the persisting points of absolute space.
  - ...accelerating with respect to the persisting points of absolute space.
- Then draw a new diagram with the matter uniformly boosted but the persisting points of absolute space the same.
  - This is physically distinct on Newtonian spacetime: the matter is all moving at a different velocity with respect to the persisting points of absolute space.
  - But if we ditch the temporal 'rigging' (i.e. facts about which spacetime point on one slice is which spacetime point on another slice), then the distinction disappears: the two scenarios are no longer physically distinct.
  - In doing so, we move to *Galilean spacetime* (sometimes: *neo-Newtonian spacetime*), which has no meaningful notion of absolute velocity.
  - *But* if we say that a line is *straight* iff any three points on that line at different time slices are collinear, we retain a distinction between straight an curved lines—and therefore a notion of absolute acceleration. (Technically, we retain an *affine connection*.)

- Multiple models of Newtonian gravitation in Newtonian spacetime all correspond to the same model of Galilean spacetime.

This might seem weird, but:

> Again, it might seem strange that some points have a spatial distance between them when others do not, but points don't have to have every property that we can think of. (Huggett 1999: 194)

Dainton (201) sums up the situation as follows:

> The move to Galilean spacetime solves the problem posed by the undetectability of absolute velocity. Velocity is the measure of how much distance is traversed in a given time; since points within successive hyperplanes are not at any distance from one another, it no longer makes sense to talk of absolute velocity, of how fast a body is moving relative to absolute space.
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> So by situating Newtonian dynamics in neo-Newtonian spacetime, the most serious Leibnizian objection is overcome. Since absolute velocities are no longer meaningful, the Newtonian is no longer guilty of positing innumerable physical states of affairs that are empirically undetectable and so indistinguishable.

Some Recent Work

Huggett's dynamical shift — gravity cancels out the acceleration — Knox.

Newtonian Spacetime Relationism

1. The advocate of this doctrine rejects absolute space, and maintains that all spatiotemporal facts are facts about the relations between material bodies, but these relations now include a distance relation between non-simultaneous events.

2. The Newtonian relationist will say that a body is at *absolute rest* if the spatial distance between its successive temporal stages at different times is zero, and an object is in *absolute uniform motion* if its successive temporal stages are separated by the same spatial distance per unit time.

3. The Newtonian relationist has no trouble accommodating the bucket. In the stationary case, the successive bucket-stages are aligned on top of one another in spacetime. In the rotating case they are not: each stage is rotated to some degree with respect to its immediate predecessor.

4. Once all distance and direction relations between material objects are specified, the entire system can be regarded as situated or "embedded" in a full Newtonian spacetime, a four-dimensional continuum of points, some of which are occupied, and many are not. The relationist will not regard this spacetime as a real entity, but as a fictional representation that is useful for purposes of calculation and prediction: for, once the relational system is so embedded, the entire mathematical apparatus that Newtonians have devised can be deployed by the relationist.

5. Maudlin concludes, "Relations that are sufficiently rich can provide the means for explaining inertial effects."