The passage of time and relativity

The issue of the existence of the objective passage of time is one of the most persistent and controversial philosophical problems. It is often suggested that physics, with its subject-independent, non-perspectival approach to reality, is either incapable of describing this phenomenon, or plainly implies that it is intrinsically inconsistent. One particular argument against the objective character of the flow of time invokes the question of its speed. Since the passage of time is supposed to be some kind of motion, it should make sense to ask how fast this motion is. But this question immediately embroils us in the seemingly hopeless task of explicating the details of this velocity: its exact value, the units in which it is measured (seconds per second?) and the like. The commonly accepted view is that the purported speed at which time flows cannot be properly represented within the framework of physical theories. In this paper I will argue that actually in special relativity there is a basic concept which can be used to express the rate of the passage of time, namely the concept of a four-velocity. I will give arguments why this notion satisfies the basic requirements for a representation of the universal flow of time, and I will repel some objections that can be brought against the proposed approach.

The argument from the unintelligibility of the rate of the passage of time is succinctly formulated by Huw Price in his 1996 book:

> […] if it made sense to say that time flows then it would make sense to ask how fast it flows, which doesn't seem to be a sensible question. Some people reply that time flows at one second per second, but […] a rate of seconds per second is not a rate at all in physical terms. It is a dimensionless quantity, rather than a rate of any sort. [1, p. 13]

One possible reply to this argument could be that the rate of the passage of time should be measured not in seconds per "ordinary" second, but rather seconds per hyper-second, where hyper-units of time refer to the meta-time with respect to which the original time passes. But this sets us on a path to an infinite regress (meta-meta-time with respect to which the meta-time passes, and so on), as convincingly argued for by J.J.C. Smart [2] and D. Williams [3].

An alternative response has been formulated by Tim Maudlin. He simply questions the premise that dimensionless quantities are unphysical, or in any other sense defective. Here is how he makes his point:

> […] it is necessary and, I suppose, a priori that if time passes at all, it passes at one second per second. But that hardly makes the answer either unintelligible or meaningless. Consider the notion of a fair rate of exchange between currencies. If one selects a standard set of items to be purchased, and has the costs of the items in various currencies, then one may define a fair rate of exchange between the currencies by equality of

> purchasing power: a fair exchange of euros for dollars is however many euros will purchase exactly what the given amount of dollars will purchase […] What, then, is a fair rate of exchange of dollars for dollars? Obviously, and necessarily, and a priori, one dollar per dollar. […] A rate of one second per second is no more a dimensionless number than an exchange rate of one dollar per dollar is free of a specified currency. [4, pp. 112-113].

Since an exchange rate of dollars for dollars is perfectly intelligible, even though trivial, the same should apply to the purported rate at which time passes.

Another but closely related objection against the flow of time comes under the heading of "No alternative possibilities" (NAP). Even if the dimensionless rate of flow is acceptable, the problem is that there is no possible alternative as to its value: by logical necessity the speed at which time passes must equal 1 [5]. Maudlin repels this argument by using yet another analogy: the fact that John is necessarily as tall as himself does not make the "exchange rate" of his height for his height defective. Still, there is the lingering doubt that the fact that time necessarily flows at the rate of one second per second indicates that there is no actual motion involved here: time "passes" with respect to itself in the same sense as a road "goes" from one city to another.

In the talk I will show how to supply Maudlin's defense of the objectivity of the passage of time with a physical representation of this phenomenon in terms of the relativistic four-velocity. We will see how this analysis can further strengthen his arguments against his opponents.

Bibliography

[1] Huw Price, *Time's Arrow and Archimedes' Point*, OUP: Oxford 1996.

[2] J.J.C. Smart, "Spatialising time", *Mind*, 64, (1955), 239-241.

[3] Donald Williams, "The myth of passage", *Journal of Philosophy* 48, (1951), 457-472.

[4] Tim Maudlin, *The Metaphysics within Physics*, OUP: Oxford 2007.

[5] Tim Maudlin, "A rate of passage", *Manuscrito* 40(1) 2017, https://doi.org/10.1590/0100-6045.2017.V40N1.TM.