
10th May, 1956.

My dear McCrea,

I have been reading your correspondence with Dingle in Nature, and though I am not tempted to think that Dingle is right, it is not clear that you have made a clear case either, if your position is both that the time shift would be experimentally verifiable in an appropriate experiment, and that the principle of general relativity can be accepted in the form that only relative movements of different material bodies are relevant to their physical experience".

In the latter part of your letter you contrast the world-paths of two possible observers, one remaining on terra firma whom you say describes a single geodesic, and the other who travels far and fast describing, in all, segments of four geodesics; ^{but} ~~and~~ this "explanation" of the supposed absolute difference in their temporal history during their separation is not really fully satisfying if you consider that you in your chair and your clock on the mantelpiece are both supported against the force of attraction of the earth, and are not really

in a state of free fall such as the description of a world geodesic would imply. Of course g is not an intolerably great acceleration, but it would in fact be quite sufficient to allow the traveller to obtain very high velocities, so that instead of imagining him as suffering crushing accelerations for three short periods you could match his ^{gravitational} ~~palpitational~~ experience, that is to say, I suppose, his curvature in relation to geodesics, with that of the stationary observer on earth.

Some people, in fact, do seem to attach great importance to these high accelerations, in the example discussed between you and Dingle, though I imagine you are not among them.

I should much like to know if you would agree in checking the purely kinematic situation implied by relativity theory, special or general, in a case a little more realistic than that which you discussed in Nature, namely to allow a vehicle to standardize its accelerations, or its gravitational field, in whichever way you choose to regard it, by hanging a weight on ^{a good} ~~the~~ spring balance and using the engines as a servo-mechanism to maintain the pointer at a fixed level, so that subjectively the contents of the vehicle experience a constant gravitational field, and ^{to study} the effect of this on clocks of various kinds - pendulum clocks, vibrating quartz rods, (and a beautiful caesium clock on the mantelpiece) ^{as well} ~~as~~ as on organic clocks, let us say a sitting

of eggs and a newlyborn baby, for the last of which it is to be observed at the end of the journey whether she is approximately 19 years old or 290. The kinematic specification of the journey then consists in maintaining the acceleration at $981 \frac{c}{s}$, for five years (the year for this purpose being simply $\frac{c}{g}$), reversing the direction of the thrust for the next ten years, and reversing again at the fifteenth year, completing the journey at the end of twenty. People looking for catches are inclined to suspect any apparent discontinuities in the course of events, so that these changes may be specified as consisting of a short subjective time, say three or four minutes, coasting without the use of the engines, while a heavy flywheel, carried for the purpose, is turned through the necessary number of degrees to reverse the orientation of the vehicle. Some, however, may prefer to have an engine at each end, and so obviate any alleged time-disruptive consequences of this simple manoeuvre.

The kinematic specification of the acceleration subjectively experienced implies that if any rarefied gas or dust is encountered, the engines ^{shall} take up the additional load without deviating from the kinematic programme laid down. All these precautions, in fact, are solely for the purpose of precluding confusion due to extraneous arguments which, experience has shown, enter easily into this question.

(2) proof
plus 100
42.1 cm/A²)

May I now assume it to be verifiable that the furthest extent of the proposed voyage would take the vehicle to a distance of about 140 ^{c₀} ~~or~~ 150 light years from its starting point, that remarkable changes are observable in the colour of the sun as viewed from the vehicle, and that terrestrial clocks will have advanced about 290 years, whereas the most juvenile passenger is still in her twentieth year? *All the ships chronometers agree excellently?*

If that is the agreed quasi-observational basis, the various clocks in the vehicle having kept very good time with each other and with the biological phenomena also in progress, the time shift is not quite easily to be ascribed to the relation between the two world-paths, which begin and end together, and the world geodesics, to which at any time they are tangential. You would seem to need, also, some sort of reference perhaps to a ~~substrate,~~ *sub-straight* or perhaps to the large masses of very distant nebulae.

Anyway, I wonder if you can throw any light on the residual difficulties I have tried to indicate.

Sincerely yours,