THE PRINCIPLE OF RELATIVITY AND THE 'COSMIC FIREBALL'

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The problem of the existence and relativity of inertial frames is considered in historical perspective and in the light of modern knowledge, concerning the structure of the universe, with particular reference to the discovery of the cosmic background black-body radiation.

Just over a hundred years ago (1877) the greatest mathematical physicist of the nineteenth century published a little book on the principles of dynamics bearing the title *Matter and Motion*. In discussing Newton’s First Law of Motion, Clerk Maxwell endeavoured to provide an *a priori* justification of it. Having dealt with the experimental arguments for the law, he suggested that our conviction of the truth of the law might be strengthened by considering the consequences of denying it. If, at a given instant a body in motion were left to itself, subject to no external force, and its velocity did not remain constant, its instantaneous change of velocity would have a definite direction and magnitude, which he maintained would have to be the same whatever the time or place of the experiment. In the first place, he supposed the law be that the velocity diminished at a certain rate which might be so slow that no experiments on moving bodies could detect the diminution of velocity in hundreds of years. The velocity referred to in such a hypothetical law could only be the velocity referred to a point absolutely at rest, for if it were a relative velocity its direction as well as its magnitude would depend on the velocity of the point of reference. Consequently, if when
referred to a certain point the body appeared to be moving northward with diminishing velocity, we would only have to refer it to another point moving northward with a uniform velocity greater than that of the body to find that the body would then appear to be moving southward with increasing velocity. Clerk Maxwell therefore concluded that such a hypothetical law would be devoid of meaning, unless the possibility of defining absolute rest and absolute velocity was admitted into physics, and that the denial of Newton’s law was "in contradiction to the only system of consistent doctrine about space and time which the human mind has been able to form".

Nevertheless, Joseph Larmor, who edited the 1920 and 1925 editions of Maxwell’s little classic, evidently had some misgivings about this argument, for he supplemented Maxwell’s remarks with an elaborate footnote in which he claimed that Maxwell’s argument could be made "more definite". He pointed out that observation showed that the more isolated a body was from the influence of other bodies, the more nearly would its velocity remain constant with reference to an assignable frame of reference. A frame of space and time with respect to which this principle is strictly valid is called (after James Thomson) a frame of inertia. Given one frame of inertia, any other frame moving with uniform motion in a straight line with respect to it is also a frame of inertia. For local purposes a first approximation to a frame of inertia is one fixed with reference to the surrounding landscape; but astronomers have to adopt a frame containing the axis of the earth’s diurnal rotation, which in a further analysis has to be corrected for the very slow movement of the earth’s axis that is revealed by the precession of the equinoxes, and so on. In Larmor’s view, such a frame of inertia represents in its practical essentials the Newtonian absolute space and time, being "the simplest and most natural scheme of mapping an extension into which dynamical phenomena can be ‘fitted’".

An obvious weakness running through Clerk Maxwell’s argument is that a priori we could begin by substituting acceleration for velocity in his discussion. Larmor made a similar criticism when he pointed out that, since Newton’s concept of dynamical force depends on the rate at which the velocity of the body on which it acts is changing with the time, it might legitimately be queried why this particular measure should correspond to objective nature rather than one involving, for example, the velocity also, or the rate of change of the acceleration.

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2 Ibid., Appendix I, p. 137.