On Synchronization and Desynchronization in Rotating Frames and a Recent Paradox

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Abstract

The issue of synchronization of clocks in rotating frames is addressed in the context of a counter-intuitive problem (known as Selleri paradox (SP)) put forward by F. Selleri. The paradox concerns a theoretical prediction regarding the one-way-speed (OWS) of light grazing the circumference of a rotating disc. The essential content of SP is that, simple kinematics together with some symmetry arguments predict, challenging the correctness of the relativity theory, an anisotropy in the OWS of light with respect to an "inertial observer" attached to the edge of the rotating disc, in the limit of zero acceleration. The claim apparently finds its empirical support in the well-known Sagnac effect. The paradox is even apparently better posed in the light of a recent "modified Sagnac experiment" by Wang et-al. (Phys. Letts.A, **312**, 7-10, 2003) where the inertiality of the observer which is attached to the linear segment of the uniformly moving fibre is automatically guaranteed whereas in order to have zero acceleration of the observer in the rotating disc context one needs to consider the size of the disc and its angular speed tending to infinity and zero respectively. The paper argues that SP not only challenges the internal consistency of the special relativity theory but also as a ramification, undermines the basic tenet of the conventionality of simultaneity thesis of relativity. The responses of SP so far available in the literature are not fully satisfactory. The inadequate responses are often plagued by error or ambivalent observations. The present paper analyses the problem in a novel way by recasting the paradox in the Galilean world and thereby revealing, in a subtle way, the lacunae in the reasoning leading to the fallacy. To advance the argument, the standard and non-standard synchronizations of clocks in the relativistic as well as in the Galilean world are discussed. In the rotating disc context the often made claim that the "desynchronization" of clocks can be viewed as the "root cause" of the Sagnac effect has been put under the scanner. It is held that of the two types of desynchronization discussed in the literature, one is dependent on the synchronization convention and therefore is merely a theoretical artifact, while the other, although a convention free entity is unable to qualify itself as the physical cause of the effect. Finally, in spite of the weak points in the reasoning leading to the paradox, Selleri's observation regarding the superiority of the absolute synchrony over the standard one for a rotating observer, has been upheld.

Keywords: Special relativity, rotating frame, Selleri paradox, Sagnac effect, synchronization of clocks, desynchronization, speed of light, conventionality of simultaneity.