Relativistic Effects in Motion and Observations of Celestial Bodies

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Accuracy of modern astronomical observations is getting so high that in order to understand what we observe and how to get physically and astronomically meaningful information from the observations, a general-relativistic consideration is inevitable. The influence of general relativity is not confined to some small corrections to Newtonian models. On the contrary, the whole concept of astronomical reference frames and astronomical observations should be re-considered from the relativistic point of view.

We begin with discussing the problem of relativistic astronomical reference frames. Although a substantial progress has been made here during last several years, some questions are still to be answered. A set of general questions is how to generalize some Newtonian concepts which are of great importance for astronomy onto the relativistic framework: terrestrial rotating reference frame, precession, nutation, rotation with respect to distant celestial bodies, etc. The concepts, being related to a reference frame as a whole rather than to an infinitely small test observer, are of Newtonian (Euclidean) origin and, generally speaking, lose their clear [intuitive] meaning in curved (Riemannian) space-times. More specific question is related to rotational state of motion of the relativistic reference systems. It turns out that the property of two reference systems to show no rotation with respect to each other is not transitive (and even not symmetric, in a sense) in the framework of general relativity. We consider possible ways to overcome these difficulties.

We review also the relativistic effects in astronomical observations which are to be accounted for at the modern level of accuracy. We discuss relativistic effects in both translational and rotational motions of celestial bodies as well as those in modelling various kinds of astronomical data.