Concepts of Space-time and Measurement Units

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Abstract:

With the rapid development of time-space measurement techniques, such as atomic clocks, astronomy satellites, space telescopes, and VLBI, SLR, LLR, GNSS et al, the spatial and temporal scales to measure is expanding, and the measurement precision is also continuously improved. Space measurement uncertainty is nearly of the order of 1E-12, and the timing uncertainty is even better than that of 1E-15. The range of precision space-time measurement is from the space near Earth, the Earth-Moon system, extended to the solar system, even to the cosmological scales. Then there must be accurate theoretical models to be suitable with the highly precise measurements. Now, general relativity and quantum mechanics are the theoretical basis of large-scale space measurement and precision timing. Time, space, gravitation, and light are the basic issues of science and technology. The basic concepts of them are introduced. The basic rules of space-time metric and the units of space and time are discussed. The basic ideas are as follows:

a) Light and electromagnetic waves are the basic objects of space measurements. All substances have characteristics of "null-like" energy absorption and releasing (radiation). The absorption and releasing of energy presents the quantum properties. The propagation of radiation energy in space-time is of the wave form.

b) The proper (intrinsic) frequency, which is observed by the observer with the same temporal state of the source, is determined by the physical attribute of light emitter (or the source), while the observed frequency of light (for any observer) is depended not only to the source, but also to the temporal states (space positions and relative speeds) of the observer and the source.

c) The speed of light propagation is affected by the medium in space-time, but independent to the source.

d) A special null-like energy should be carefully chosen as a reference for the measurement of space-time. The unit of time is defined by the adopted "proper frequency" value of the null-like energy and the unit of length is done by the adopted "proper wavelength".

e) The "spatial distance" and "time interval" of two "events" are associated with the observer, and they are not invariables. Or in other words, the observed results of time and space length observed by different observers are different for the same events. There is no absolute time and space. Different observer has different time and space.

f) There exists "space-time interval" between the two universal events which is nothing to do with the observers. The "time interval" and "space distance" are just the different perception forms of "space-time" interval. For the metric of space-time, a coordinate reference system must be constructed, in which a special observer's reference frame is chosen and is expanded in some rules to the outer space in order to cover a certain range of space-time. Generally, different coordinates have different units of space and time.

Key Words: space-time metric, general relativity, quantum mechanics, reference frame, precision timing