MISCONCEPTIONS ON RELATIVITY
GRAVITATION AND COSMOLOGY

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(Dated: (Original date: June 30, 2002 - This Version date: July 26, 2008))

Abstract

Fifteen misconceptions involving Relativity, Gravitation and Cosmology are exposed, along with corrections.
Introduction

By perusing several elementary Physics textbooks, I was astonished with the inclusion of misconceptions dealing with Relativity, Gravitation and Cosmology. I have to confess that most Physics textbooks published in English can be recommended for beginner students.

The misconceptions and the corrections

1. "Time is relative so there is not some master grandfather clock that controls time in the Universe". (sic)

[The comoving cosmic time is such a master clock; when I say that the Universe is 14 billion years old, this is absolute time. A comoving observer is always at rest relative to the matter in its neighborhood. All the literature in Cosmology is based in such observers].

2."The laws of Physics are the same for all inertial observers". (sic)

[Einstein outlined his theory with the use of tensor notation and four dimensional spacetime; only when the laws are cast in tensor notation, and in 4D spacetime, the laws of Physics retain the same form for all observers. In three-dimensional space and common elementary mathematics, the laws of Physics can be very awkward depending on the observer. For instance, the Maxwell equations of electromagnetism can be very complicated for an observer moving relative to another at rest].

3."You define relativistic 3-momentum, and then you assume conservation when there are no forces". (sic)

[In fact, the concept of force must be generalized from Newtonian Physics into Special Relativity, so that, the relativistic force is equal to the proper time derivative of relativistic linear momentum, but the textbooks forget to generalize the 2nd. law. The examples in the textbooks only deal with collisions, when the external force is supposed to be null].

4."Today, when atomic clocks are transported from one place to another, the time dilation of Special Relativity is to be always taken into account." (sic)
[Because differences in gravitational potential also affect measures of time, the difference in gravitational potential is also to be taken into account.]

5.”Inertial reference systems are those where Newton’s laws are valid.” (sic)

[Newton’s laws are only valid for low speeds and weak gravitational fields, but the definition of inertial systems of references is also necessary in Special Relativity, where Newtonian laws need modification.]

6.”Special Relativity is not Classical Physics.” (sic)

[Classical Physics means Non-Quantum Physics; so that, Special Relativity and General Relativity, along with the Electromagnetism, are all Classical Theories.]

7.”The principle of equivalence states that gravitation and acceleration are equivalent.” (sic)

[This is only valid at a given point and its infinitesimal neighbourhood. There is no point in substituting a gravitational acceleration for, say, a centripetal acceleration. Both may be numerically equal in a certain point of space; nevertheless, the gravitational acceleration decays with the inverse square of distance, while the centripetal one increases with distance so that, if they are equal in one point they may be different in other locations.]

8.”Newtonian Physics deals with low speeds.” (sic)

[It should be always remembered that it is only valid for weak gravitational fields. If the speeds are not low, but the gravitational field is weak, Special Relativity is to be taken into account; if the gravitational field is intense, General Relativity must play a rôle.]

9.”Edwin Hubble studied distant galaxies.” (sic)

[In fact the linear relation is valid for not too distant galaxies, which were those he could observe in the year 1929.]

10.”The principle of equivalence says that a homogeneous gravitational field is completely equivalent to a uniformly accelerated reference frame.” (sic)

[This is correct, but represents a trivial consequence of the true principle. See #7.]

11.”The gravitational field is an example of a vector field.” (sic)

[Einstein’s General Theory of Relativity, is based on the assumption that the gravitational field is represented by a metric tensor, which represents the potentials of gravitation. This metric tensor is not a vector.]

12. ”With Einstein’s postulates, i.e., the equivalence and covariance principles, we find
General Relativity.” (sic)

[In fact, the mentioned postulates can support other theories, which have different field equations, like for instance, scalar-tensor gravitation.]

13. ”The Universe has a center.” (sic)

[In most models, the Universe is homogeneous, so that any point is equivalent to any other one, and may be considered the center. I call this the egocentric observer postulate.]

14. ”’Dark matter” and ”dark energy”, are the same thing, because of Einstein’s mass-energy relation”. (sic)

[In fact, dark matter and dark energy are different concepts: the first one responds for the missing of visible matter, which should represent about 33% of all matter, but only 5% is visible; 27% is the dark matter. Dark energy, which is 67% of the energy density in the Universe, is there because the Universe must have been made of critical energy density, which is the value that turns the Universe a ”flat” tri-dimensional one; the agent causing this dark energy, responds for the acceleration of the present Universe].

15. ”The Universe expands, so it accelerates”. (sic)

[What accelerates, is the rate of expansion, and not the ”center”, which is at any point].

Conclusions

Even good and recommendable textbooks should make an effort to bring a correct picture also in Relativity, Gravitation and Cosmology: what we commented in this paper should be taken as an alert on otherwise high praised books.

Acknowledgements

I thank Prof. M.M. Som and F.M. Gomide for conversations on the subject of this paper. I recognize the good service of Mr. Marcelo Fermann Guimarães in typing this and many other manuscripts, and the encouragement of Albert, Paula and Geni.