Re: GR ?

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- *From*: Tom Roberts <tjroberts@xxxxxxxxxx>
- *Date*: Sun, 17 Jul 2005 17:02:06 GMT

Significant Zero wrote:

> "Tom Roberts" <tjroberts@xxxxxxxxxx> wrote in message
> news:XFiCe.4226$Ih7.2317@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
> | In modern physics, energy is the conserved Noether current corresponding
> | to a time translation. In systems without time translation invariance,
> | energy is not conserved, and loses much of its usefulness.
>
> A point I am interested in Tom, thanks. So do you think that in GR time translation is invariant ?

In GR, any manifold that has a timelike Killing vector will have invariance for time translation along that vector (that's what "Killing vector" means [named after Prof. Killing, of course]). Manifolds without a timelike Killing vector do not.

> A "Killing vector" is necessarily a vector field on the manifold, but the word "field" is usually omitted.

> and can you conceptualise a system in which time
> and distance proportionate variance produced a conserved energy situation ?
> and would this have any relevance to GR ?

I have no idea what you are asking ("time and distance proportionate variance" means nothing to me).

Note that any manifold with a timelike Killing vector is called "stationary" −− in essence as long as you use that Killing vector as a time coordinate, then nothing changes over time (nothing moves). Here's a short and incomplete list of such manifolds:
Minkowski spacetime, everywhere
Schwarzschild spacetime, exterior to the horizon
Kerr geometry, external to the horizon
... there are others

As we observe objects moving in the world we inhabit, any manifold modeling our world has no timelike Killing vector.

> But can a *Langrangian (or *Hamiltonian) always be considered as being applied to a continuous symmetry in GR.?

Obviously you don't know what a Lagrangian is. That's too complicated for me to attempt to explain here -- find a good book and study it. But in a nutshell, the Lagrangian of a system expresses the "action" of the system as it evolves, and the principle of least action states that variations of the Lagrangian around the system's actual dynamical path must be zero. Using the calculus of variations can then yield differential equations for the system known as its "equations of motion"; they can be solved for the trajectories of the various components of the system. In Newtonian mechanics this can yield the trajectory of a cannonball, for instance. In GR the equation of motion is the Einstein field equation (originally discovered another way by Einstein).

The "continuous symmetries" discussed here, and which are the subject of Noether's theorem, are SYMMETRIES OF THE LAGRANGIAN. That is, if energy is to be conserved in a given system then the Lagrangian for that system must not change under a time translation -- the Lagrangian must be independent of time.

> Its certainly confusing to me as it
> appears that a Langrangian is based on Pythagoras's and Euclidean geometry which seem incompatible with GR.

In Newtonian mechanics, Euclidean geometry is implicitly used, and geometrical terms do not appear in the Lagrangian. In GR, the Lagrangian explicitly includes the Ricci scalar, which is a geometrical term. This is why GR needs no prior geometry (geometry implicitly assumed and forever fixed) -- in GR the geometry of the manifold is dynamical, as are the trajectories and interactions of objects.

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