Equivalence Principle (EP)

1. EP has several interpretations.
   (a) Global form: inertial mass = gravitational mass (more generally four-momentum). Does not make sense in general relativity since four-momentum is not well-defined.
   (b) Local form: Einstein's equations. Gravitational mass a parameter appearing in asymptotic expression of solutions of Einstein's equations.

2. EP need not be problem of principle in TGD.
   (a) Gravitational interaction couples to inertial four-momentum which is well-defined as classical Noether charge associated with Khler action.
   (b) Very close analogy of TGD with string models suggest the same.
   (c) Only if one assumes that gravitational and inertial exist separately and are identical, one ends up with potential problems in TGD.
   (d) In cosmology mass is not conserved. This does not mean breaking of Poincare invariance in Zero Energy Ontology (ZEO). Four-momentum depends on the scale of causal dia mond (CD).

3. EP in quantum TGD.
   (a) Inertial momentum is defined as Noether charge for Khler action.
   (b) One can assign to Khler Dirac action quantal four-momentum. Its conservation is however not at all all trivial since imbedding space coordinates appear in KD action like external fields.
   (c) It however seems that at least for the modes localized at string world sheets the four-momentum conservation could be guaranteed by an assumption motivated by holomorphy.
   (d) Quantum Classical Correspondence (QC
   (e) suggests that the eigenvalues of quantal four-momentum are equal to those of Khler four-momentum. QCC would imply EP!
   (f) This generalizes to Cartan subalgebra of symmetries and would give a correlation between geometry of space-time sheet and conserved quantum numbers

4. The understanding of EP at classical level has been a long standing head ache in TGD framework. The eventual solution looks disappointingly trivial. in the sense that its discovery requires only common sense. The most elegant understanding of EP at classical level relies on following argument suggesting how GRT space-time emerges from TGD as an effective notion.
   (a) Particle experiences the sum of the effects caused by gravitational forces. The linear superposition for gravitational fields is replaced with sum of effects describable in terms of effective metric in GRT framework. The effective space-time metric is identified as the sum of M^4 metric and the deviations of the metrics of various space-time sheets from M^4 metric to which particle has topological sum contacts.
   (b) The effective metric is not in general imbeddable to $M^4 \times CP_2$. Under lying Poincare invariance is not lost but global conservation laws cannot hold true for the effective metric. This suggests that energy momentum conservation translates to the vanishing of covariant divergence of energy momentum tensor.
   (c) By standard argument this implies Einstein's equations with cosmological constant Λ: this at least in statistical sense. Λ would parametrize the presence of topologically condensed magnetic flux tubes.
   (d) Gravitational constant and cosmo logical constant would come out as predictions. More precisely: dimensionless constant n characterizing Planck length is predicted: $L_P^2 = R^2/n$, R is CP_2 radius.

5. To sum up: TGD is microco pic theory of gravitation and GRT its statistical limit obtained by replacing M^4 with metric with effective metric. The experimental challenge is to make many-sheetedness visible. One can of course ask whether EP or something akin to it could be realized for preferred extremals of Khler action.

   (a) In cosmological and astro physical models vacuum extremals play key role. Could small deformations of them provide realistic enough models for astrophysical and cosmological scales in statistical sense.

   (b) Could preferred extremals satisfy something akin to Einstein's equations? Maybe! The mere condition that the covariant divergence of energy momentum tensor for Khler action vanishes, is satisfied if Einsteins equations with cosmological terms are satisfied. One can however consider also argue that this condition can be satisfied also in other manners.

   (c) For instance, four-momentum currents associated with them be given by Einstein's equations involving several cosmological "constants". The vanishing of covariant divergence would however give a justification for why energy momentum tensor is locally conserved for the effective metric and thus gives rise to Einstein's equations.