AFFINELY INVARIANT FIELD THEORY

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In any theory of fields propagating in space and time, the metric properties of a space-time are operationally defined by the coupling of these (nongravitational) fields to the geometrical (gravitational) quantities of the space-time. The geometrical quantities used to con struct this coupling may be chosen to be derived from a metric tensor in a minimal way. This is the case we put in the standard relativity and the weak equivalence principle by hand, and where we are not able to ask for a physical (dynamical) reason for these to be valid.

The Mach program just considers the inertial properties, which are represented in a field theory by the existence of a metric tensor, to be derived dynamically from the structure and the motion of the matter in general, i.e. from the structure and the motion of the universe. Hence, we have to try for a theoretical scheme, in which the metric tensor is the result of a coupling, which does not use it beforehand, and which may be more com plicated, but is reduced (at least in an approximation) to the known metrical coupling we are used to.

The least extension of the Lorentz group repesented by the metric tensor is the affine group, therefore we consider affinely invariant field theories. Comparing local actions (the one by Schr—dinger for instance) with non-local ones we see, that the main problem is not the theory of the gravitational field itself, which may be constructed by various "elementary" field entities such as tetrads, or connections, but the construction of the coupling of the non-gravitational fields to it. Usually, the metric is constructed already in the action integral before solving the equations for subsystems in the real universe. In this case, the existence of the metric tensor is a kinematical property again and the task to produce it dynamically may not be solved.

If we require the effective field equations for a local system to be second order partial differential equa tions, an affinely invariant theory (not presuming the existence of a metric tensor beforehand) has to be non- local, the action being a multiple integral over the manifold considered.