01/29/03

Phys 776

- Brief review of GR
- Mathematical tools
- Hamiltonian formalism (initial value form.)
- Black Holes & BH thermo
- Quantum Gravity

(link:) GR in a nutshell (lecture notes)
R.M. Wald - GR..

Review of GR.

Newtonian Gravity
+
special relativity

$F^i = m_I a^i$ — inertial mass

$F_G^i = m_G g^i = -m_G \varphi_{,i}$ — gravitational mass; φ: grav. potential

(Equivalence of inertial and gravitational mass)

$m_I = m_G$

$\Rightarrow \boxed{a^i = -\varphi_{,i}}$

independ. of which body

Newton's law $\rightarrow$ $\boxed{\nabla^2 \varphi = 4\pi G \rho_{G\,active}}$

when $m_{G\,passive} = m_I$, it's hard to see if $m_{G\,active} \neq m_{G\,passive}$

After transforming away the local gravitational field (by changing coordinates or going to a freely falling frame).

$\rightarrow$ What is left are the tides

${}^N\Phi^i{}_j$ - newtonian tidal tensor

${}^N\Phi^i{}_j = g^i{}_{,j} = -\varphi_{,ij}$, Newton's law:

$$\boxed{{}^N\Phi^i{}_i = -4\pi G \rho}$$

two neighboor freefalling points:

A $\overset{c^i}{\longrightarrow}$ B , $c^i = x_A^i - x_B^i$

$\frac{d^2x^i}{dt^2} = -\varphi_{,}{}^{i}$, $\ddot{c}^i = \ddot{x}^i|_B - \ddot{x}^i|_A$

infinitesimally:

$\ddot{c}^i = \lim_{|c|\to 0} \frac{(\ddot{x}^i(B) - \ddot{x}^i(A))}{|c|} |c| = -\varphi_{,}{}^{i}{}_{j} c^j = \Phi^i{}_j c^j$

Special Relativity: Spacetime 4d manifold of events, labeled by x^μ

$\mu = 0,1,2,3$

$+$ a metric: $ds^2 = g_{\mu\nu}(x)\, dx^\mu dx^\nu$

- Minkowisky space: $\boxed{ds^2 = -dt^2 + dx^2 + dy^2 + dz^2}$ $\forall x^\mu$ (its constant).

- In a general spacetime: $\underbrace{g'_{\mu\nu}}_{\text{10 independent components at } p} = \underbrace{\partial_\mu x^\alpha \partial_\nu x^\beta}_{\text{16 numbers at } p} g_{\alpha\beta}$; $\boxed{\text{at a point } p}$

$= 10$ to put $g_{\mu\nu}$ in standard form ($\eta_{\mu\nu}$) $+ 6$ Lorentz transformation parameters.