

# Physics 320: Astrophysics: Problem Set 4

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## I. GRAVITY V. ELECTRICITY

The electromagnetic interaction is much stronger than the gravitational interaction. Estimate how much stronger by computing the ratio of the magnitudes of the electric and gravitational forces between two electrons. Does it matter how far apart the electrons are?

## II. HYPERPSEUDOSPHERE

In analogy with our derivation of the metric (or line element) for a hypersphere, derive the polar spherical metric for the hyperpseudosphere  $(R, \chi, \theta, \varphi)$  defined by

$$x^2 + y^2 + z^2 + w^2 = -R^2. \quad (1)$$

Find the ratio of the circumference to the diameter of a circle on the pseudospherical slice  $\theta = \pi/2$ . What is the geometry of the slice  $\chi = \chi_0$ ?

## III. CMB REDSHIFT

The CMB radiation has been propagating to us since the universe became transparent at a temperature of approximately 3000K. Its temperature today is about 2.73K. What is the redshift  $z$  of the CMB?

## IV. LEGISLATING $\pi$

Purportedly, Indiana House Bill #246 of 1897 would have declared  $\pi = 3.2$ , but it was defeated in the state Senate. Is there some geometry of three-dimensional space where the ratio of the circumference  $C$  to the diameter  $D$  has a constant value for all circles that is 3.2 exactly? If so, write the corresponding metric (or line element).