Problem Set #4

Astro 2: Spring 2012

Due: May 1, 2012 (in class)

Problem 1

Special Relativity can be entirely derived using the axiom that the speed of light is the same for all observers (even though the observers may move relative to one another), and the assumption that the laws of physics should work the same for any non-accelerating observers (inertial reference frames). The derivation of effects such as time dilation follows from just algebra and the pythagorean Theorem.

In a similar way (though using more difficult mathematics), General Relativity can be derived from one simple (and observationally correct) idea, plus special relativity. What is this simple idea? Explain it.

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Problem 2

Curved space can be understood quite well intuitively by thinking about spaces (surfaces in this case) which are two-dimensional instead of three-dimensional. Derive the relationship between luminosity, distance, and flux (apparent brightness) for 2D flat space. This is analgous to the Inverse Square Law in 3D space. Hint: Read the section in the textbook where the 3D relationships were derived, and make analgous arguments.

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Problem 3

If you draw a triangle on a *curved* surface, the interior angles will add up to more or less than 180°. In the former case we say that the curvature is positive, and in the latter case we say the curvature is negative.

A good example of a positively curved surface is a sphere. For a fixed sitance bewtween an observer and a light source, would you see more or less flux from the light source if you were on the surface of a beach ball, as contrasted to being on flat 2D space? Hint: Imagine a light source at the 'north pole' of the sphere, and image how the light 'thins out' as you move away from the pole. Now figure out whether the light thins out more or less compared to 2D flat space.

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Problem 4

Calculate the Eddinton Limit on the luminosity of a star of $60M_{sun}$. Look up the main sequence luminosity of such a star. Speculate on why no stars are found that are much more massive than this. (Answer: $1.8 \times 10^6 L_{sun}$)

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Problem 5

Suppose a $10M_{sun}$ black hole is accreting matter and radiating at the Eddington Limit. Approximate the radiating area as that of a circle with area $A = \pi R^2$, where $R = 10R_{Sch}$. Assume for simplicity that the whole disk has the same temperature.

(a) What temperature would be expected for such a disk? (Answer: $\approx 2.5 \times 10^7$ K) Reminder: A disk has two sides.

(b) Now assume that its mass is instead $10^9 M_{sun}$. What temperatue is expected? (Answer: $\approx 2.5 \times 10^5$ K)

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