The gravitational field has only a relative existence...
Because for an observer freely falling from the roof of a
house - at least in his immediate surroundings - there exists
no gravitational field. Einstein 1907

Introductory Astronomy

Week 6: Relativity and Black Holes

Clip 9: Happy Thoughts

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Relativistic Gravity

- $F = \dfrac{GMm}{R^2}$ is no good. Whose R ? When?
- Maxwell gives a relativistic version of $F = \dfrac{kQq}{R^2}$ in terms of electromagnetic fields
- We need a field theory for gravity but Maxwell's idea will not work – mass is not conserved. Energy-Momentum is conserved but not invariant
- What is a gravitational force anyway??

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The Principle of Equivalence

- Observer in free fall – only gravity acts - there is no gravitational force. Stars and galaxies are in free-fall!
- Conversely, accelerating frames exhibit gravitational force in the absence of gravity
- Gravitation at one event can be completely cancelled by choosing a suitably accelerating frame – letting go
- Gravity is acceleration?
- Tidal Forces - the change in a_g in space and time – are truly gravitational

3

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Gravity is Acceleration

g

g

Gravitational Redshift

$$\lambda = \lambda_0(1 + gH/c^2)$$
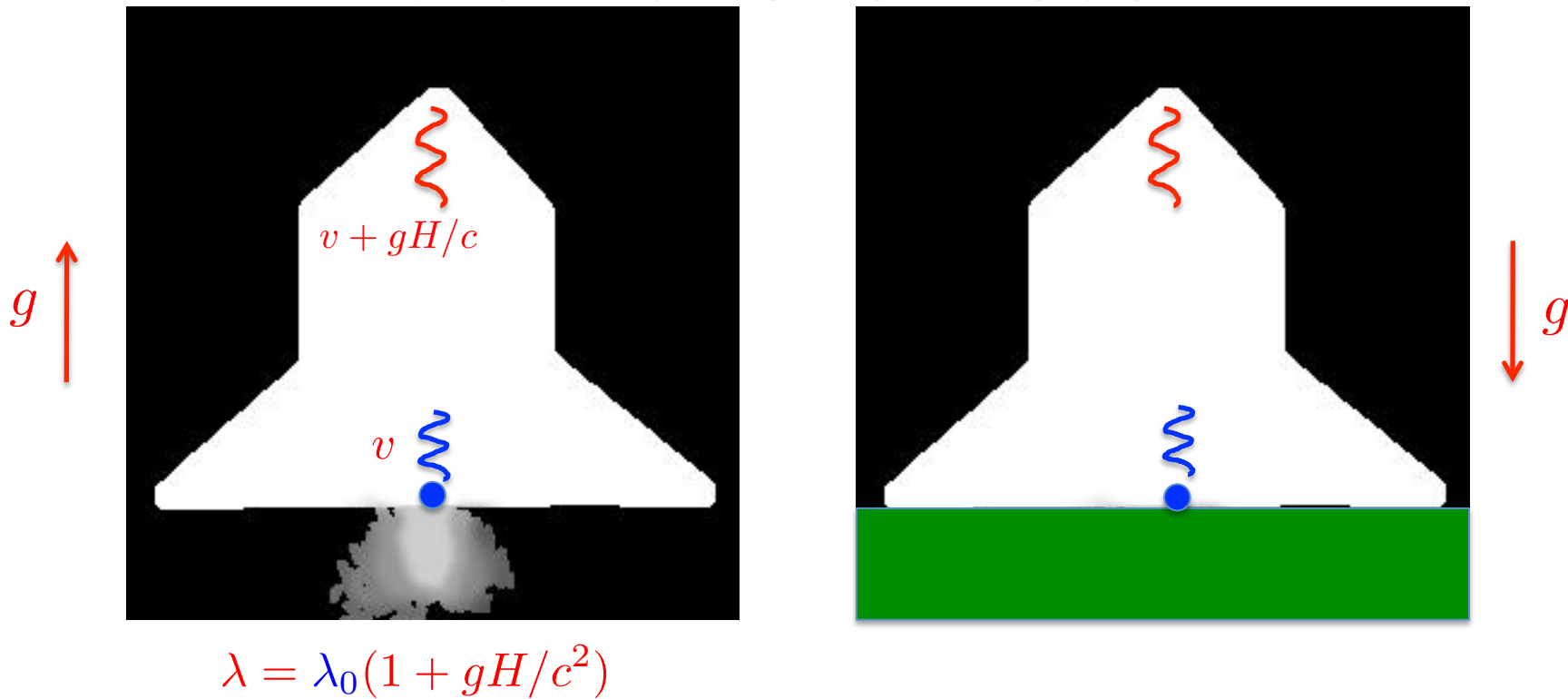
- **Equivalence Principle**: lower clock runs **slow**

- **Pound Rebka 1959 measure** the effect over height of tower in **Jefferson Lab**: complete agreement

- **GPS** system needs to account for **redshift**

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Credits

- Rocket Ship: D. Pape, University at Buffalo, http://resumbrae.com/ub/dms423_f05/13/

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