

General Relativity and Cosmology

- * WED 12:15 — 14:00, THU 14:15 — 16:00**
- * Problems classes: integral part of the course**
First problems class: THU, 25 April
- * Oral exam at the end of the course**
> 50% score required to be admitted to final exam

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First problems class: THU, 25 April
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- * **Three bank holidays:**
1 May (WED), 30 May (THU), 20 June (THU)

Schedule

Week 1	17.4	lecture		Week 8	5.6	lecture	
	18.4	lecture			6.6	lecture	extra lecture on FRI, 7.6. from 10-12
Week 2	24.4	lecture		Week 9	12.6	lecture	
	25.4	problems class	extra lecture from 15:30 to 16:30		13.6	problems class	
Week 3	1.5	Bank holiday	shifted to FRI, 3.5. from 10-12	Week 10	19.6	lecture	
	2.5	lecture			20.6	Bank holiday	shifted to FRI, 21.6. from 10-12
Week 4	8.5	lecture		Week 11	26.6	lecture	
	9.5	problems class			27.6	problems class	
Week 5	15.5	lecture		Week 12	3.7	lecture	
	16.5	lecture			4.7	lecture	
Week 6	22.5	lecture		Week 13	11.7	problems class	
	23.5	problems class			12.7	lecture	
Week 7	29.5	lecture		"Week 14"		extra lectures?	
	30.5	Bank holiday					

Literature

- * **S.M. Carroll:** Spacetime and Geometry (Pearson)
see also: <https://arxiv.org/abs/gr-qc/9712019>
- * **Misner, Thorne and Wheeler:** Gravitation (Princeton)
- * **Hawking and Ellis:** The Large-scale Structure of Space-Time (CUP)
- * **Weinberg:** Gravitation and Cosmology (Wiley)
- * **Scheck:** Theoretische Physik: Vol. 1 — Mechanik, Vol. 3 — Klassische Feldtheorie (Springer)
- * **Landau & Lifshitz:** Vol. 2 — Classical Theory of Fields
- * **Choquet-Bruhat, DeWitt-Morette, Dillard-Bleick:**
Analysis, Manifolds and Physics (North Holland)

Website

- * Information, schedule, material can be found at

<https://wwth.kph.uni-mainz.de/cosmology-and-general-relativity/>

- * Teaching assistant:

Joey Smiga

jsmiga@uni-mainz.de

Helmholtz Institute Mainz, room 01-145

- * Solutions to be handed in at Midday on the day before the problems class: Mailbox “Wittig” at Institute for Nuclear Physics

Overview

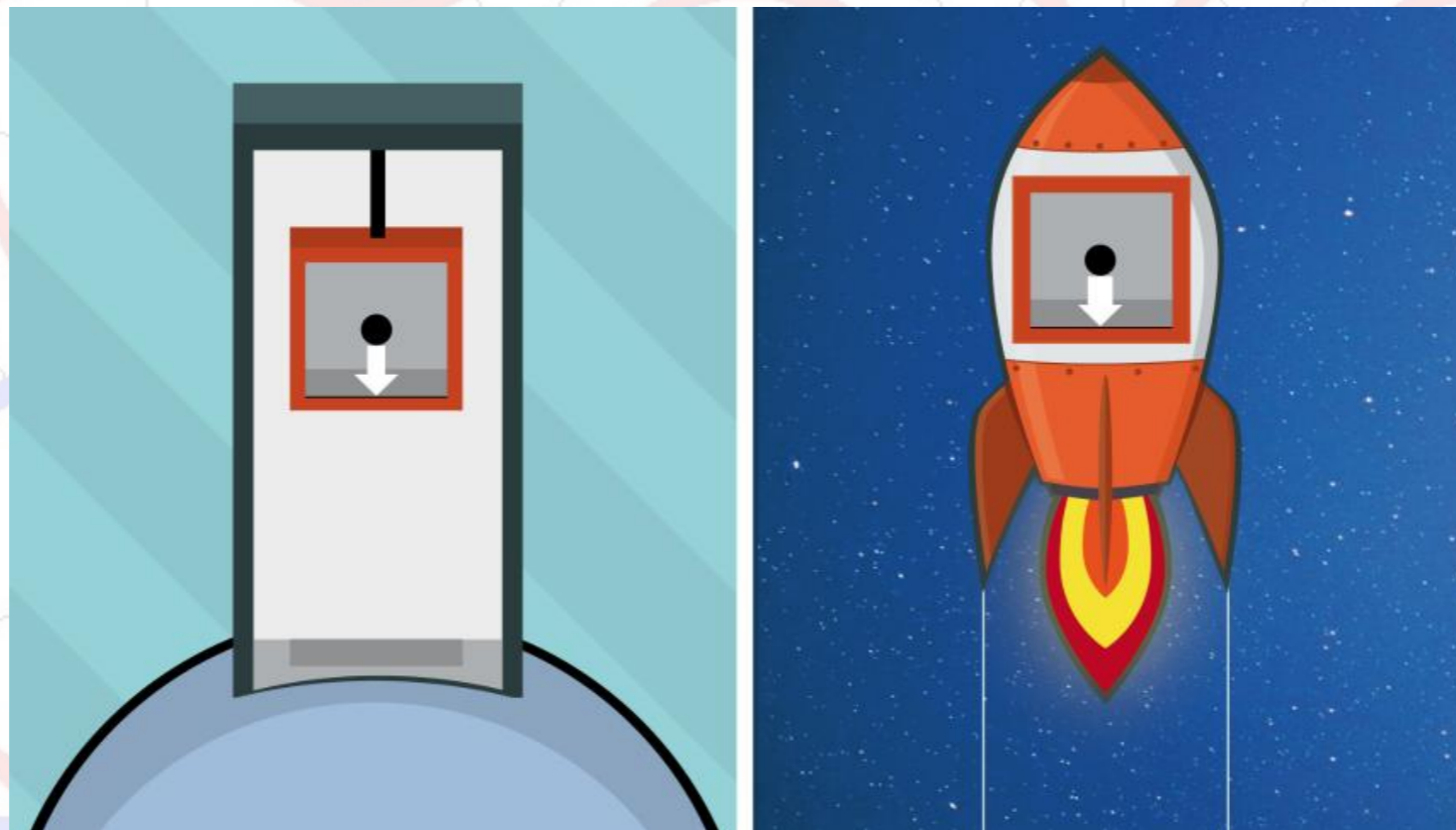
Contents

- 1. Introduction: Equivalence Principle; Special Relativity**
- 2. Differentiable Manifolds**
- 3. Einstein Field Equations**
- 4. Black Holes**
- 5. Gravitational Waves**
- 6. Cosmology**

Overview

Equivalence Principle

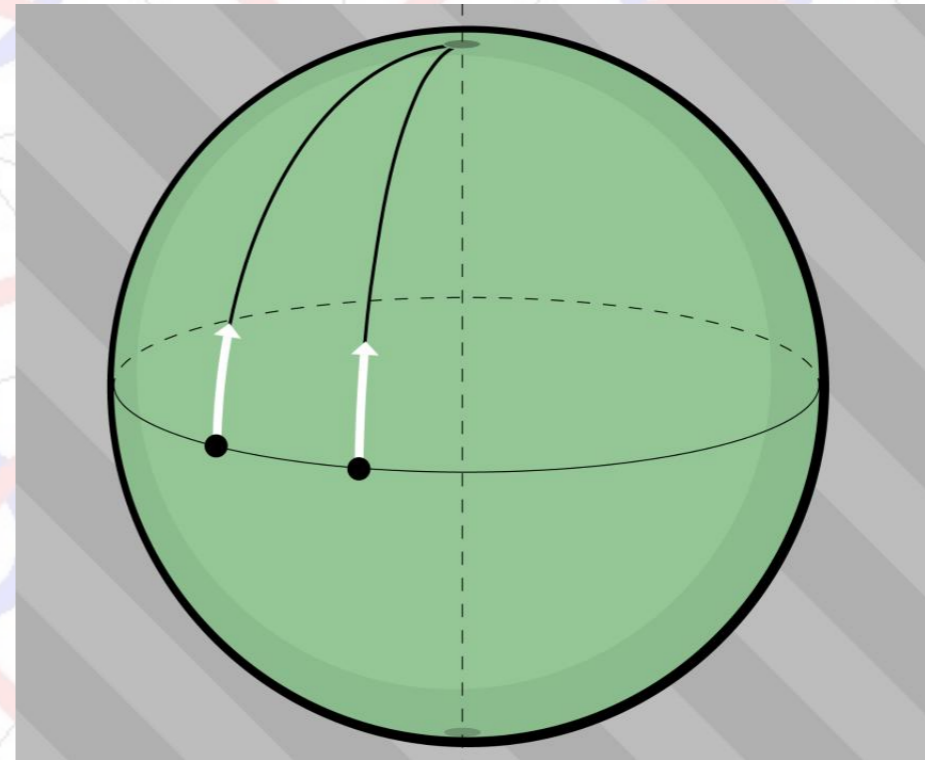
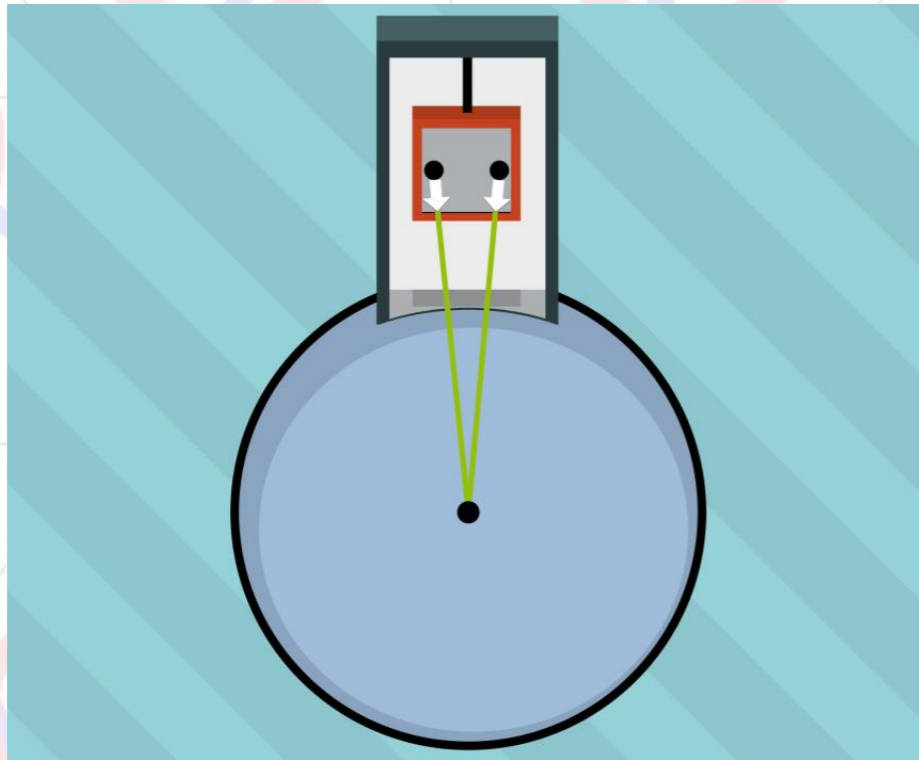
- Gravitation and acceleration cannot be distinguished



Overview

Space-Time Geometry

- **Massive bodies induce curvature of space-time**



- **Mathematical formalism: Differential Geometry**
- **Description of space-time manifold without referring to external frames**

Overview

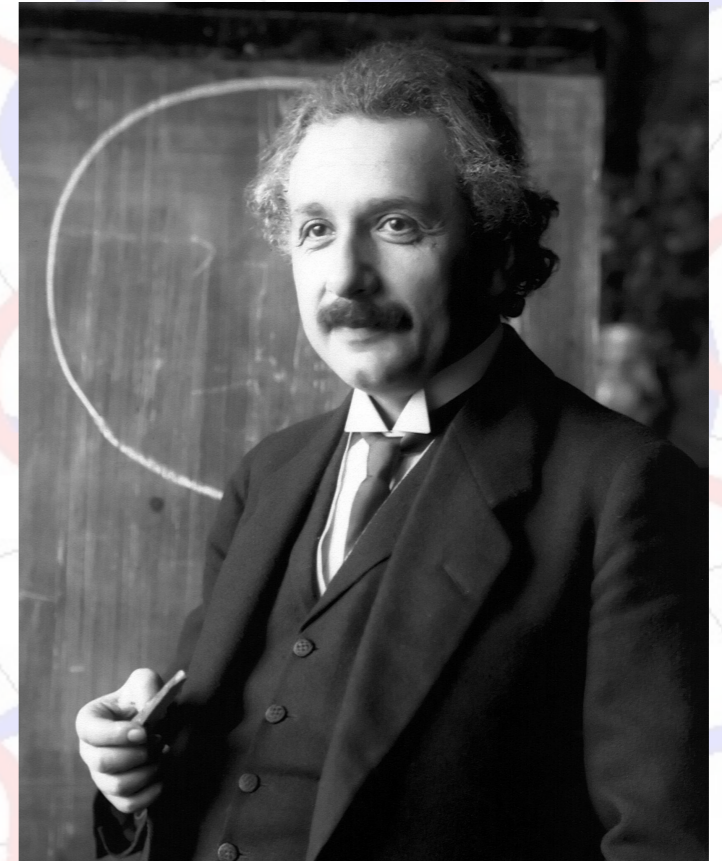
Field Equations (1915)

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G T_{\mu\nu}$$

Geometry

Matter

$g_{\mu\nu}$: Spacetime metric



- Differential equations for the 10 independent components of $g_{\mu\nu}$

Overview

Consequences of the field equations

- **Gravitational redshift**
- **Bending of light —> gravitational lensing**
- **Perihelion shift**
- **Gravitational collapse —> black holes**
- **Gravitational waves**
- **Cosmology**

Overview

Consequences of the field equations

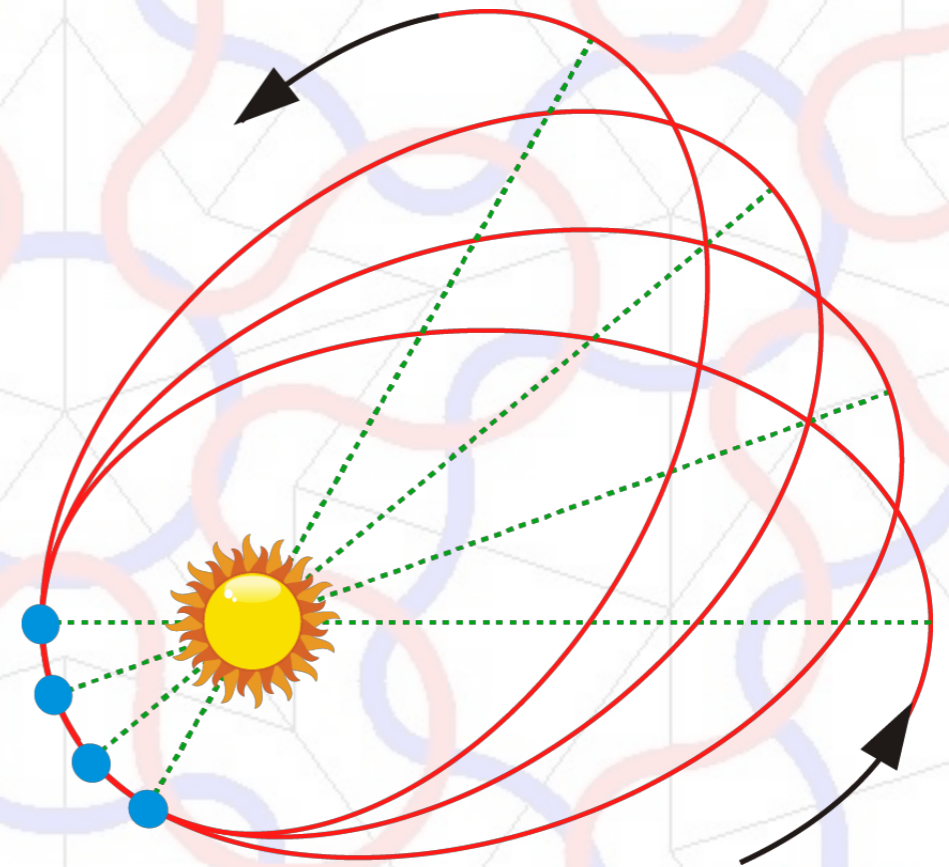
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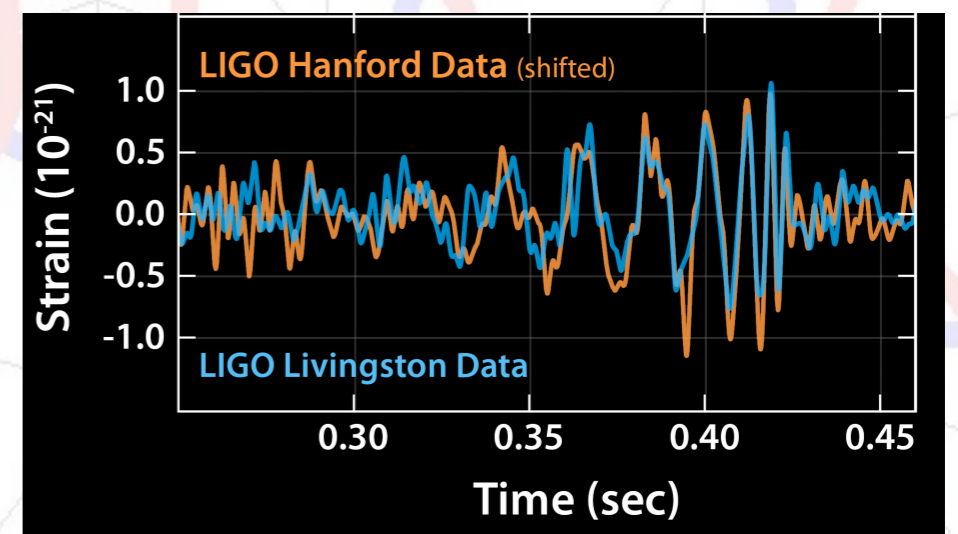
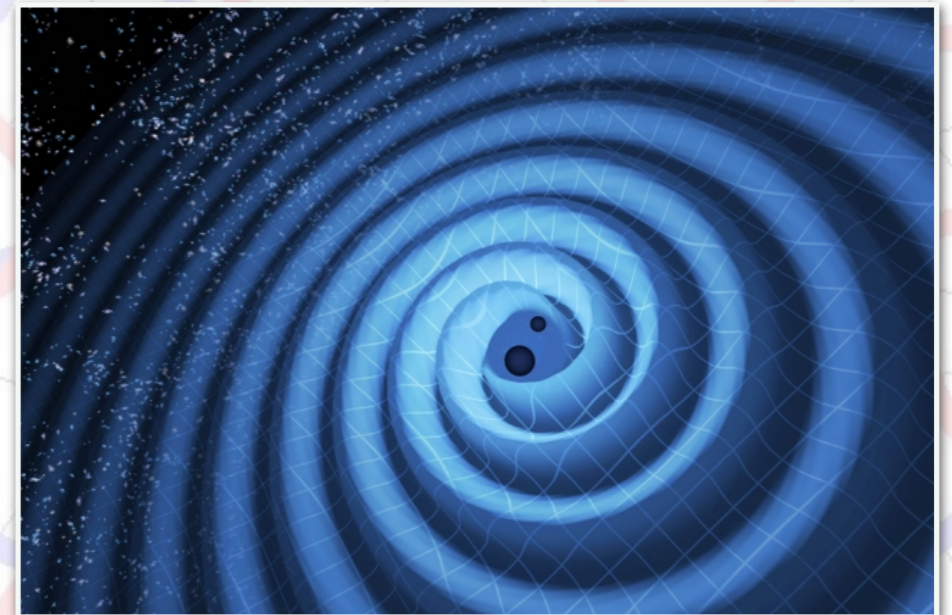
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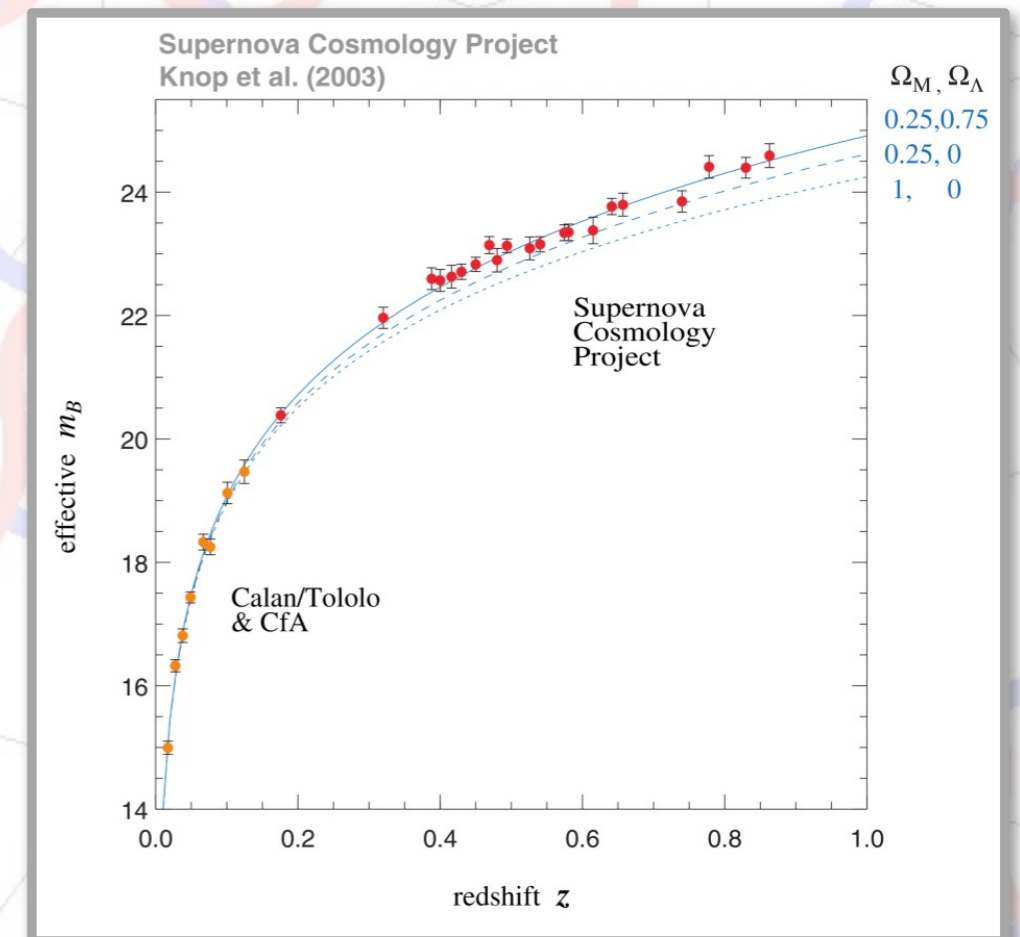
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Any Questions?