Strong gravity theory and gravitational waves

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There are 4 fundamental forces





Gravity is special!

- Acts on everything
- No screening from gravity \rightarrow feature of spacetime!



General Relativity: Curvature

- Curvature generates acceleration
 - No "force"!!
- Einstein:
 - spacetime is curved!



How do we calculate this?



Solving this equation is our job...

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We need supercomputers... E.g. Cosmos at DAMTP



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Strong gravity = non-linear

What is non-linear? Think of the stock market:





 \Rightarrow linear



\Rightarrow NON-LINEAR!

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Strongest gravity = black hole

- Time goes upwards
- green = future
- red = past



- Strong curvature ⇒ everything moves inwards
- \Rightarrow Black hole

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Black-hole analogy



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Are black holes real?

Since 1960s: very likely yes!

• X-ray binaries 1964



• Stars near galactic center



The Centre of the Milky Way (VLT YEPUN + NACO) (VLT YEPUN + NACO) (0Exropean Southern Observator)

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Are black holes real?



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Research areas: Black holes have come a long way!

Astrophysics



Gauge-gravity duality



Fundamental studies



GW physics



High-energy physics



Fluid analogies



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Gravitational Waves

- Black-hole / Neutron-Star binaries generate ripples in spacetime
- Changes in length: < atomic nucleus per km
- Indirect evidence: 1993 Nobel Prize Hulse & Taylor



How can we measure this? I On ground

• Principle: Michelson-Morley interferometer



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How can we measure this? II In space

$\bullet \sim$ Million km interferometer



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How can we measure this? III Using space

See Michael Kramer's presentation



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What will we learn?



Test Einstein's theory



Galaxy formation



Look into neutron stars



Black-hole populations







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A new window to the Universe...



... often reveals new ideas!

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