Frontiers of black hole research

- 1. Black hole astrophysics
- 2. Black hole fundamentals
- 3. Black hole speculations

Black hole astrophysics

Questions:

- Do black holes and gravitational waves have the properties predicted by GR?
- How do we unify GR and quantum mechanics into a theory of quantum gravity, allowing discreteness and uncertainty in spacetime itself?
- What happens to the information "lost" when a black hole evaporates?
- Does quantum gravity only matter near the black hole singularity, or does it affect black hole structure out to and at the event horizon? (See "Fuzzballs")

Methods:

- X-ray, optical, and radio surveys, including time variability, microlensing
- X-ray spectroscopy of accreting black holes
- Event horizon telescope
- Gravitational waves (LIGO, pulsar timing arrays, eventually LISA)
- Theoretical models, especially computer simulations of accretion flows

Black hole fundamentals

Questions:

- What is the population of "inactive" stellar mass black holes?
- Which stars make black holes, and how?
- What "seeds" the growth of supermassive black holes?
- How do supermassive BHs regulate their host galaxies, and vice versa?
- What is the physics of accretion flows and jets?
- Could primordial black holes be dark matter?
- Are there unexpected sources of gravitational waves?
- Does quantum gravity only matter near the BH singularity, or does it affect structure out to and at the event horizon?

Methods:

- Event horizon telescope
- Gravitational waves, with LISA especially promising because of highprecision measurements
- Theory, including string theory and its variants

Black hole speculations

Questions:

- Could wormholes exist in nature? Could they be usable for traversing large distances?
- Is something like "warp drive" physically possible?
- Is time travel physically possible?





Black hole speculations

Is time travel to the past physically possible?



Godel spacetime

ME 66, NUMBER 9 PHYSICAL REVIEW LETTERS

4 March 1991

Closed Timelike Curves Produced by Pairs of Moving Cosmic Strings: Exact Solutions

J. Richard Gott, III Department of Astrophysical Sciences, Princeton University, Princeton, New Jersey 08544 (Received 18 October 1990) PHYSICAL REVIEW D, VOLUME 58, 023501

Can the Universe create itself?

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FIG. 1. Two-parallel-string static solution: (x,y) plane.



