



The University of Mississippi

LSC in Mississippi: A proposal of membership

Marco Cavaglià on behalf of the UMGr²

LIGO-G070562-00-Z



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Oxford, MS

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Oxford Trivia

Population: ~ 19,000

Named by **USA Today** as one of the top 6 college towns in the nation and included in ***The Best 100 Small Towns*** in America

Famous people from Oxford:



William Faulkner
(1867 – 1962)



John Grisham
(1955 –)



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...and of course the gravity group !

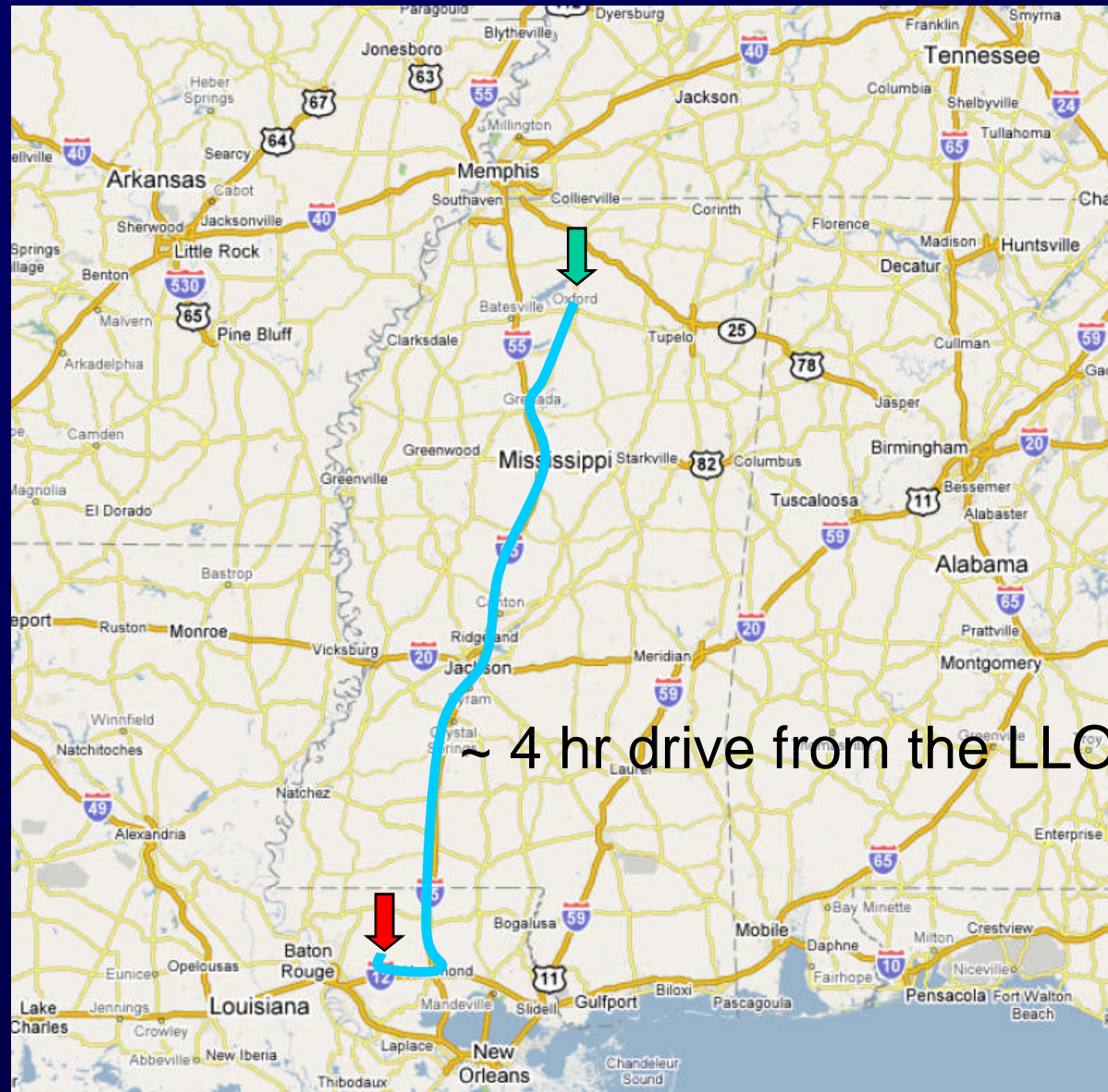


(by the way... does the background look familiar to you?)

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Ole Miss in a nutshell

- ◆ Chartered in 1844, opened to 80 students in **1848**
- ◆ **Total enrollment in 2007: 17,300**. 65% of students from MS, 18% minorities
- ◆ **679 full-time faculty** (Oxford campus). Student-to-faculty ratio: 18:1
- ◆ External funding for research, service and education > \$100M each for the past 5 yrs
- ◆ More than **20 research centers** with exceptional strengths in acoustics, biology, business, chemistry, computer science, engineering, law, medicine, pharmacy, and **physics**



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What we are renowned for

- ◆ **Sally McDonnell Barksdale Honors College** one of the nation's three finest (Reader's Digest)
- ◆ Ranked among the nation's **Top 50 public research universities**
- ◆ **\$421M endowment**, among the nation's best endowed public institutions per capita
- ◆ 18 sports teams at the NCAA's highest level
- ◆ **World's largest blues archive**





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Physics

- ◆ Undergraduate degrees: BSc, BA. Graduate degrees: PhD, MSc, MA
- ◆ **Only PhD granting Institution in MS**
- ◆ **12 full-time faculty, 11 research faculty, 2 visiting faculty**, 5 postdocs, **25 PhD students**, 2 Lab physicists, 8 MSc students, ≥ 30 undergraduates
- ◆ **Diversified research**: Acoustics, Atmospheric physics, Gravitation+Theory, High-energy, Solid state
- ◆ High-Energy: **BaBar, CMS, DØ, MICE, Pierre Auger**
- ◆ Theory: **classical and quantum gravity**, particle physics, mathematical physics



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- ◆ **Two machinists** paid by the University and the Department
- ◆ Some projects: Fiber Optic Welders (Fermilab), Hcal HB Boxes (CERN), Pill Box Cavity (UC-Berkeley), Wire EDM Samples (MS State)



- ◆ **Mississippi Center for Supercomputing Research** with two supercomputers and one 253-node Linux cluster



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The Gravity Group

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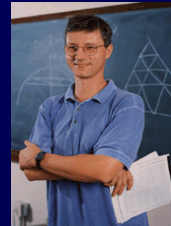
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Members

Two faculty:



M. Cavaglià



L. Bombelli

One Research Associate:



V. Cardoso

Five Graduate students:



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Research and background

- ◆ Classical gravity (numerical and theory)
- ◆ Astrophysics
- ◆ Monte Carlo methods
- ◆ Particle physics
- ◆ Quantum gravity and mathematical physics





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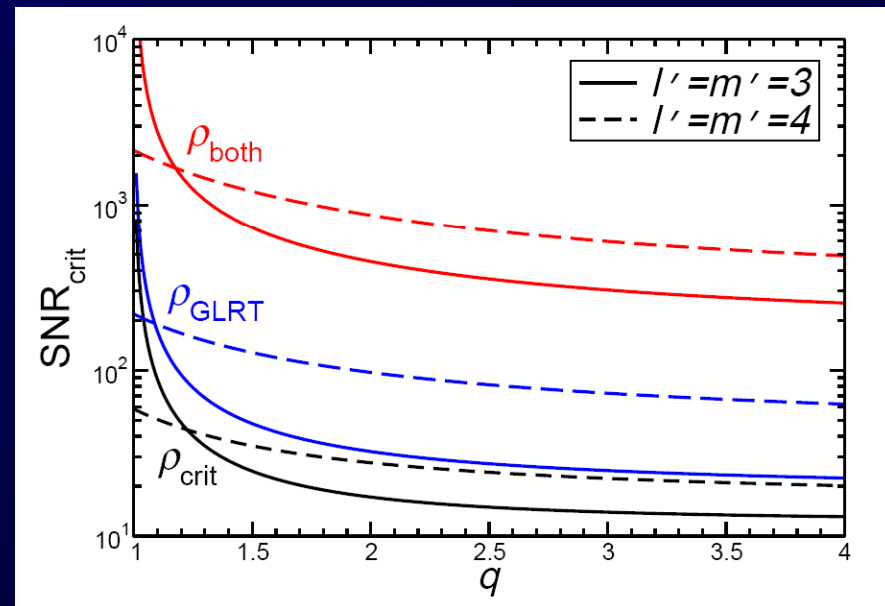
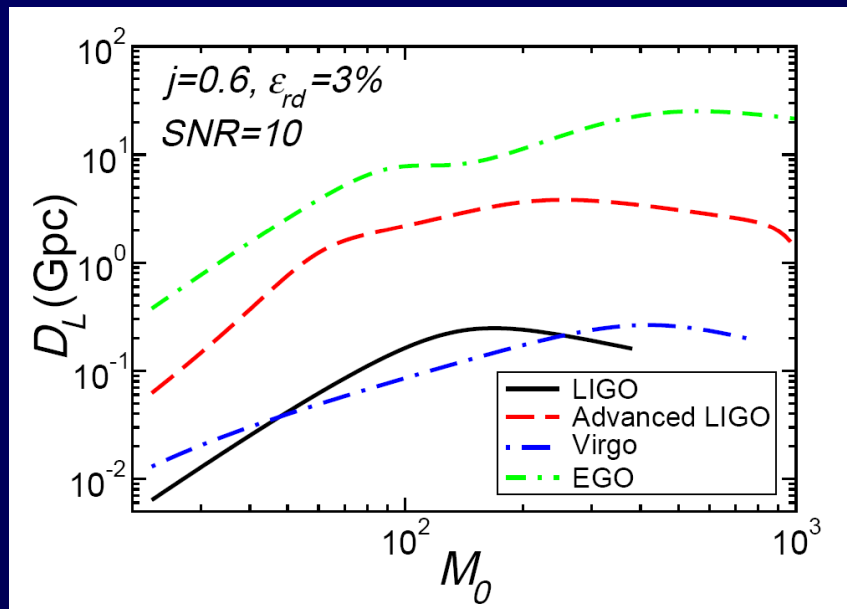
Some recent work

- ◆ Matched-filtering and parameter estimation of ringdown waveforms
- ◆ Inspiral, merger and ringdown of unequal mass black hole binaries
- ◆ Binary black hole mergers: a comparison of estimation methods
- ◆ Catfish: A Monte Carlo simulator for black holes at the LHC
- ◆ Quasinormal ringing of Kerr black holes
- ◆ Gravitational-wave spectroscopy of massive black holes with LISA



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Ringdown



arXiv:0707.1202 [gr-qc] 9 Jul 2007

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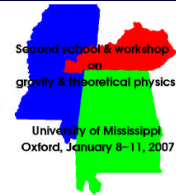


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Outreach

- ◆ Schools on gravity and theoretical physics and 4th Gulf Coast Gravity Meeting (March 2008)
- ◆ Promote science in Mississippi through local events, school lectures, and web outreach

Second school & workshop
on
gravity & theoretical physics
Oxford, Mississippi
January 8-11, 2007



Gravitational waves and their detection: the ringdown phase

Gravitational waves were theoretically predicted by Einstein in 1916, soon after the formulation of general relativity. But... do they really exist?

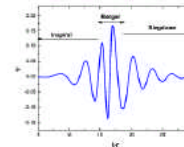
Unlike electromagnetic waves (verified experimentally by Hertz less than two decades after being predicted by Maxwell), gravitational waves have not yet been experimentally detected, although there has been an indirect verification through the observation of a [binary pulsar](#). [Hulse and Taylor](#) were awarded the Nobel prize in 1993 for this discovery.

Einstein's theory of relativity asserts that information travels at a finite speed, and never faster than the speed of light. Since Einstein's theory is so well-tested, it is reasonable to adopt this as a starting point. If we extend this result to gravity, then something must carry information about the gravitational force. These carriers are the gravitational waves. Gravitational waves are commonly referred as "ripples in the fabric of spacetime", analogous to water waves on the surface of a lake or the ocean. In practice, this means that gravitational waves are gravitational tidal forces traveling through space.

The summation show what happens to a ring of particles at rest when a plane gravitational wave hits the ring perpendicularly to it.



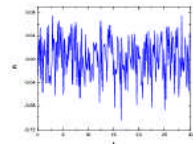
The ringing of a bell produces as we all know a *characteristic sound*. The ringing of a black hole also produces a characteristic signal, called *quasiperiodal ringing or ringdown*. This means the black hole is relaxing and settling into a new static phase.



The figure to the left shows the gravitational waveform for a typical inspiral and merger of compact bodies leading to a black hole. The waveform has three distinct phases. In the inspiral phase, the signal is basically a sinusoid and the orbits of the bodies are well described by Newtonian dynamics. The *chirp* in the signal at the end of this phase is due entirely to gravitational radiation emission: as the system loses energy, the orbital separation shrinks and the frequency increases. In the merger phase, the bodies are so close together that relativistic effects become important. The orbital parameters change very quickly in this phase, corresponding to the instant of *collision*. In the ringdown phase, the signal is an exponentially damped sinusoid. The features of this signal (ringing frequency and damping time) are independent of the process that led to it.

The leading candidate source of detectable wave black holes. The signal from such sources should. The inspiral waveform originates from that part nature of the merger waveform is largely unknown hole, and can be considered the typical sound of imagine that the distorted black hole behaves like

Typical data coming out of the detectors will not at all look like the figure above. Real data also includes all sort of dirty effects, called *noise* (see figure). Fortunately, there are well understood techniques to dig out signals from noise, so not all is lost! This requires to know with great accuracy the form of the signal at the source. Thus many research groups use supercomputers and sophisticated techniques to study gravitational waves from binary, black holes, and other processes. Gravitational waves will soon be detected!



Watch the [pictures](#) of the Gravitational and Theory Group trip to LIGO!

Home

Cool stuff

Physics

is cool

at Ole Miss!

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Proposal for LSC membership

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Roles and initial research FTE

- ◆ **M. Cavaglià** (PI for proposed LSC research): 50%
- ◆ **V. Cardoso**: 75%
- ◆ **Two full-time graduate students**: 75% & 50% (expected to increase in future)

Funding for two one-semester graduate students have been secured

Other faculty-postdoc involvement (?)



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Proposed work

- ◆ Data analysis (DAT)
- ◆ Detector characterization (OPS)
- ◆ Outreach (OUT)



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Within binary inspirals group

Focus on high-mass binaries

Study of instrumental and signal-based vetoes / optimization

Code runs, search tuning



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Investigation of environmental disturbances at the LLO

Correlation with channels

Presence at the LLO

Software analysis



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Proposed work

- ◆ Data analysis (DAT)
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Activities with MAP

Presence at the LLO

Public lectures, open houses,
summer projects

Free machine shop manpower



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Why joining LSC?

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Five reasons to join LSC

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Five reasons to join LSC

- ◆ **Closeness to the LLO:** We can easily interact and be present at the site!



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- ◆ **Solid background in gravitational research:** LSC is an undertaking in which we can effectively contribute



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We also pledge...

- ◆ Strong **University support** (Office of Research, College and Department)
- ◆ Some (initial) **funding**
- ◆ Available **infrastructures**
- ◆ A lot of **enthusiasm!**



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Thank you!

(Gravitational wave simulation)

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