

Introduction to General Relativity (aka Gravity)

Reed Clasey Essick
KICP

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Compton Lectures
University of Chicago

<https://github.com/reedessick/compton-lectures-2019>

"All the News
That's Fit to Print"

The New York Times

Late Edition

Today, some sunshine giving way to times of clouds, cold, high 28. Tonight, a flurry or heavier squall late, low 15. Tomorrow, windy, frigid, high 21. Weather map, Page A19.

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NEW YORK, FRIDAY, FEBRUARY 12, 2016

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Clinton Paints Sanders Plans As Unrealistic

New Lines of Attack at Milwaukee Debate

By AMY CHOZICK
and PATRICK HEALY

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Foreign affairs also took on unusual prominence as Mrs. Clinton sought to underscore her experience and Mr. Sanders excoriated her judgment on Libya and Iraq, as well as her previous praise of former Secretary of State Henry A. Kissinger. But Mrs. Clinton was frequently on the offensive as well, seizing an opportunity to talk about leaders she admired and turning it against Mr. Sanders by bashing his past criticism of President Obama — a remark that Mr. Sanders called a "low blow."

With tensions between the two Democrats becoming increasingly obvious, the debate was full of new lines of attack from Mrs. Clinton, who faces pressure to denounce Mr. Sanders's growing



CALTECH M.I.T. LIGO LABORATORY

A worker installed a baffle in 2010 to control light in the Laser Interferometer Gravitational-Wave Observatory in Hanford, Wash.

Long in Clinton's Corner, Blacks Notice Sanders

By RICHARD FAUSSET

ORANGEBURG, S.C. — When Helen Duley was asked whom she would vote for in the South

Courted Hard in South
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candidate she barely knew. "It makes me feel good," she said, chuckling, "that young people are listening to the elderly people." She now said she was an un-

Last Occupier In Rural Oregon Is Coaxed Out

WITH FAINT CHIRP, SCIENTISTS PROVE EINSTEIN CORRECT

A RIPPLE IN SPACE-TIME

An Echo of Black Holes Colliding a Billion Light-Years Away

By DENNIS OVERBYE

A team of scientists announced on Thursday that they had heard and recorded the sound of two black holes colliding a billion light-years away, a fleeting chirp that fulfilled the last prediction of Einstein's general theory of relativity.

That faint rising tone, physicists say, is the first direct evidence of gravitational waves, the ripples in the fabric of space-time that Einstein predicted a century ago. It completes his vision of a universe in which space and time are interwoven and dynamic, able to stretch, shrink and jiggle. And it is a ringing confirmation of

the nature of black holes, the bottomless gravitational pits from which not even light can escape, which were the most fore-



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Barry C. Barish (Caltech)



Kip S. Thorne (Caltech)



Rainer Weiss (MIT)



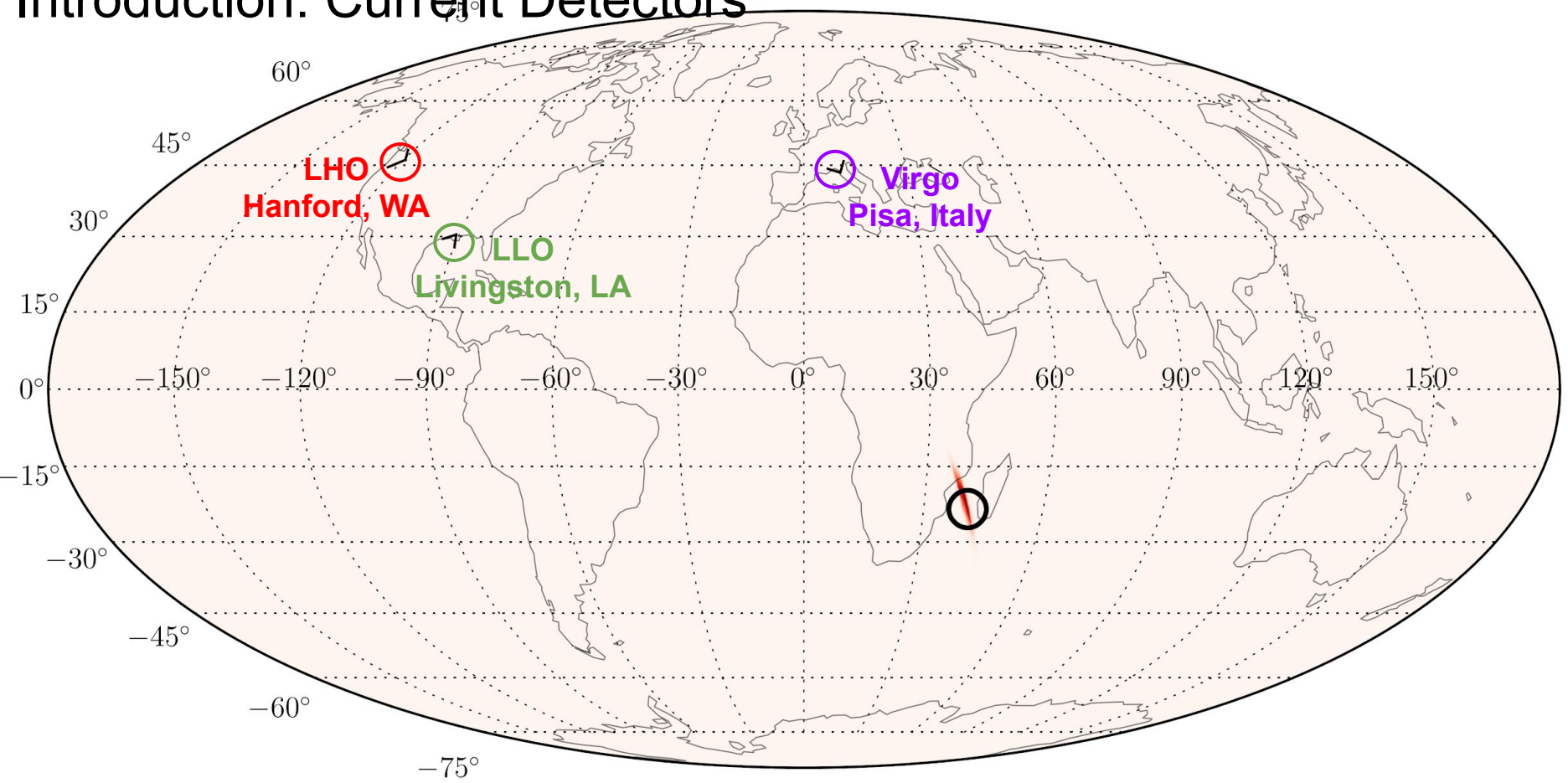
2017 Nobel Prize in Physics

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Introduction: Current Detectors



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Introduction: Astrophysical Objects

Neutron Stars and **Black Holes**

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They go by many names

- Pulsar
- Magnetar
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The mass of the sun in a ball 16 miles in diameter

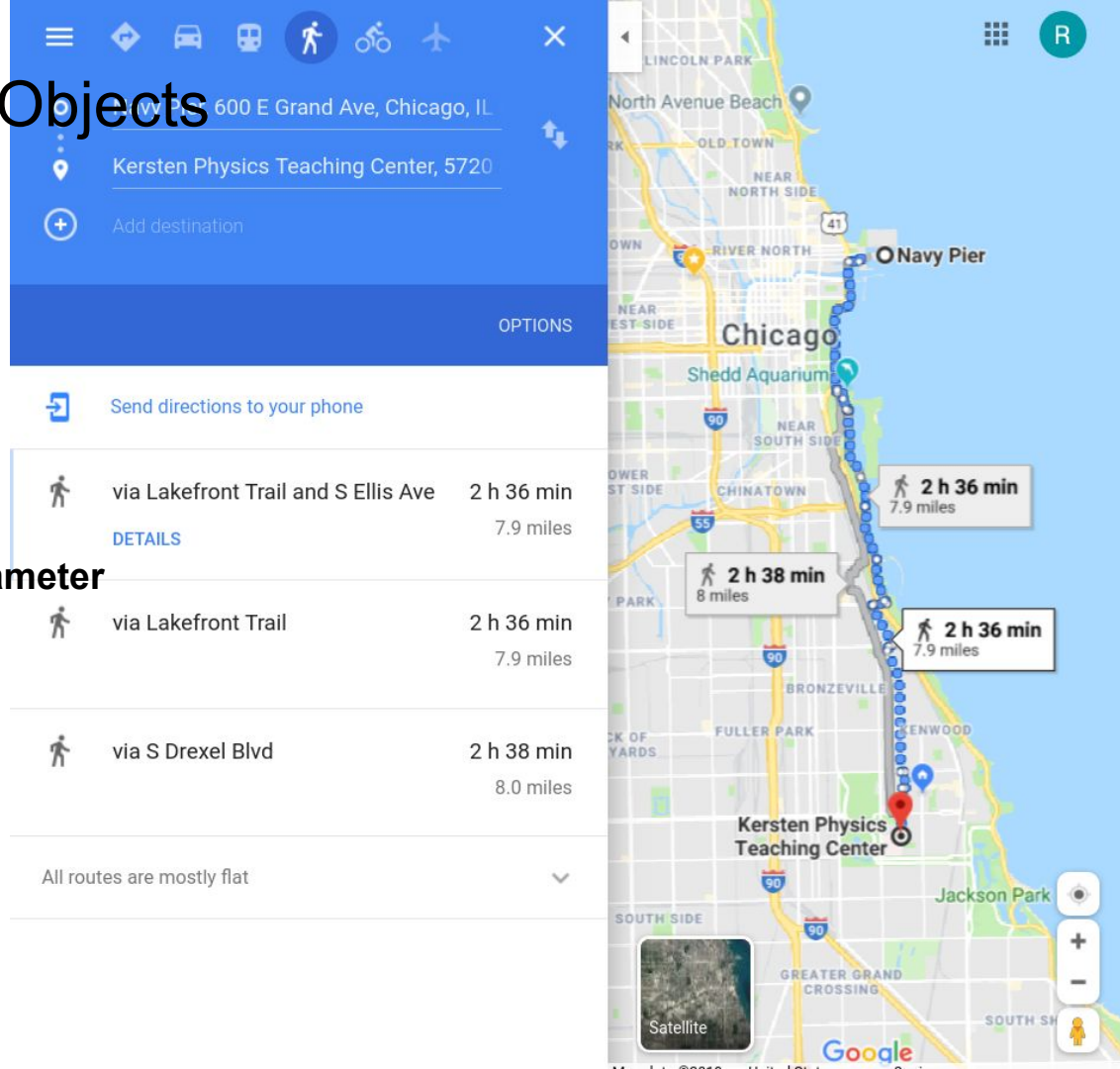
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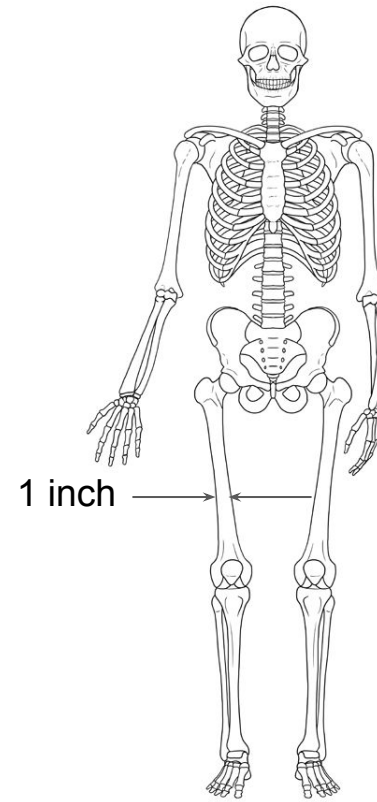
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We observe this process hundreds of millions of light-years away as *Gravitational Waves*

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- No information can travel faster than the ***speed of light***

Gravitational Waves

- Radiation carrying information about gravitating systems

Gravitational Waves

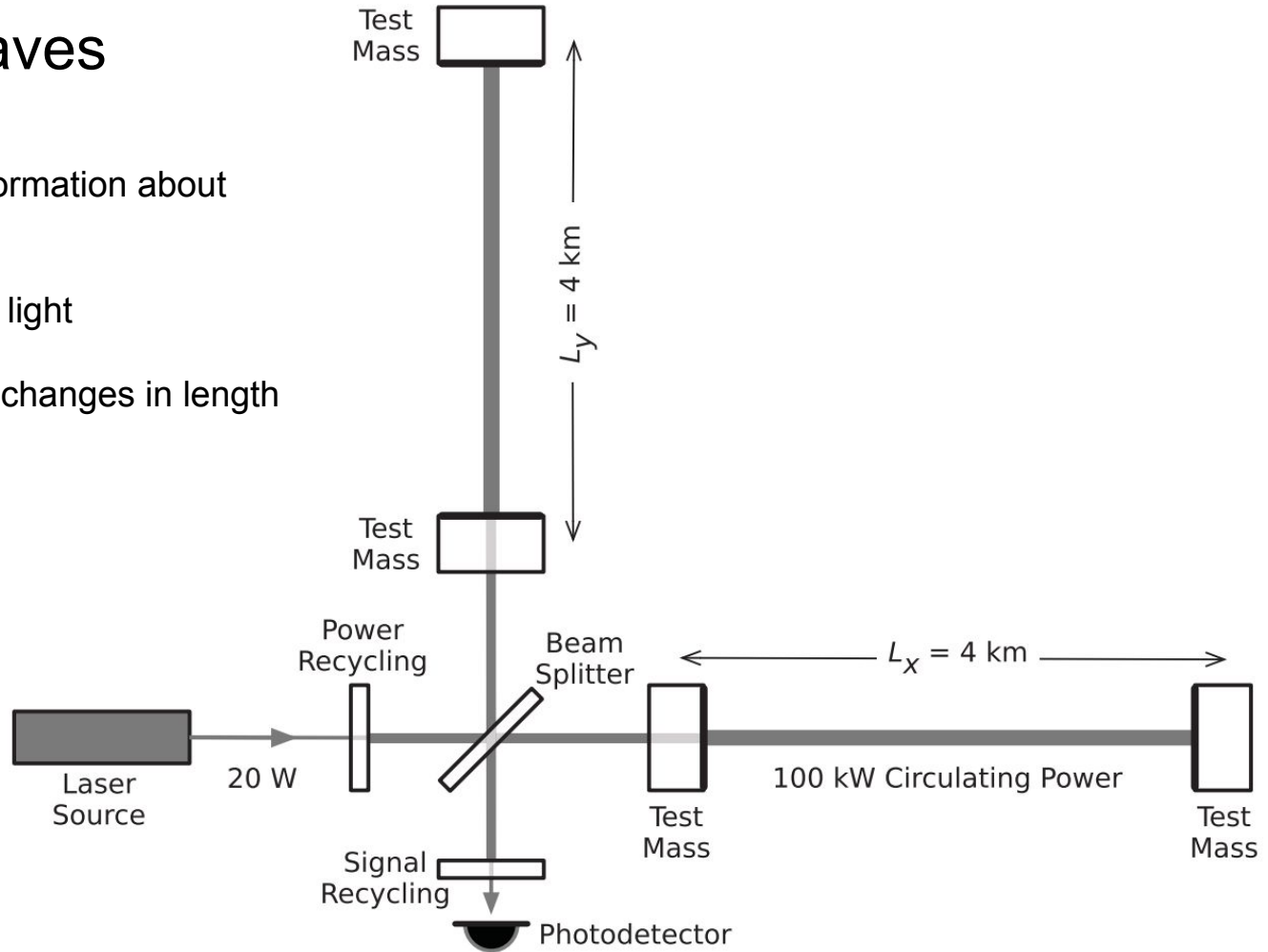
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Gravitational Waves

- Radiation carrying information about gravitating systems
- Travel at the speed of light
- Create extremely tiny changes in length between objects

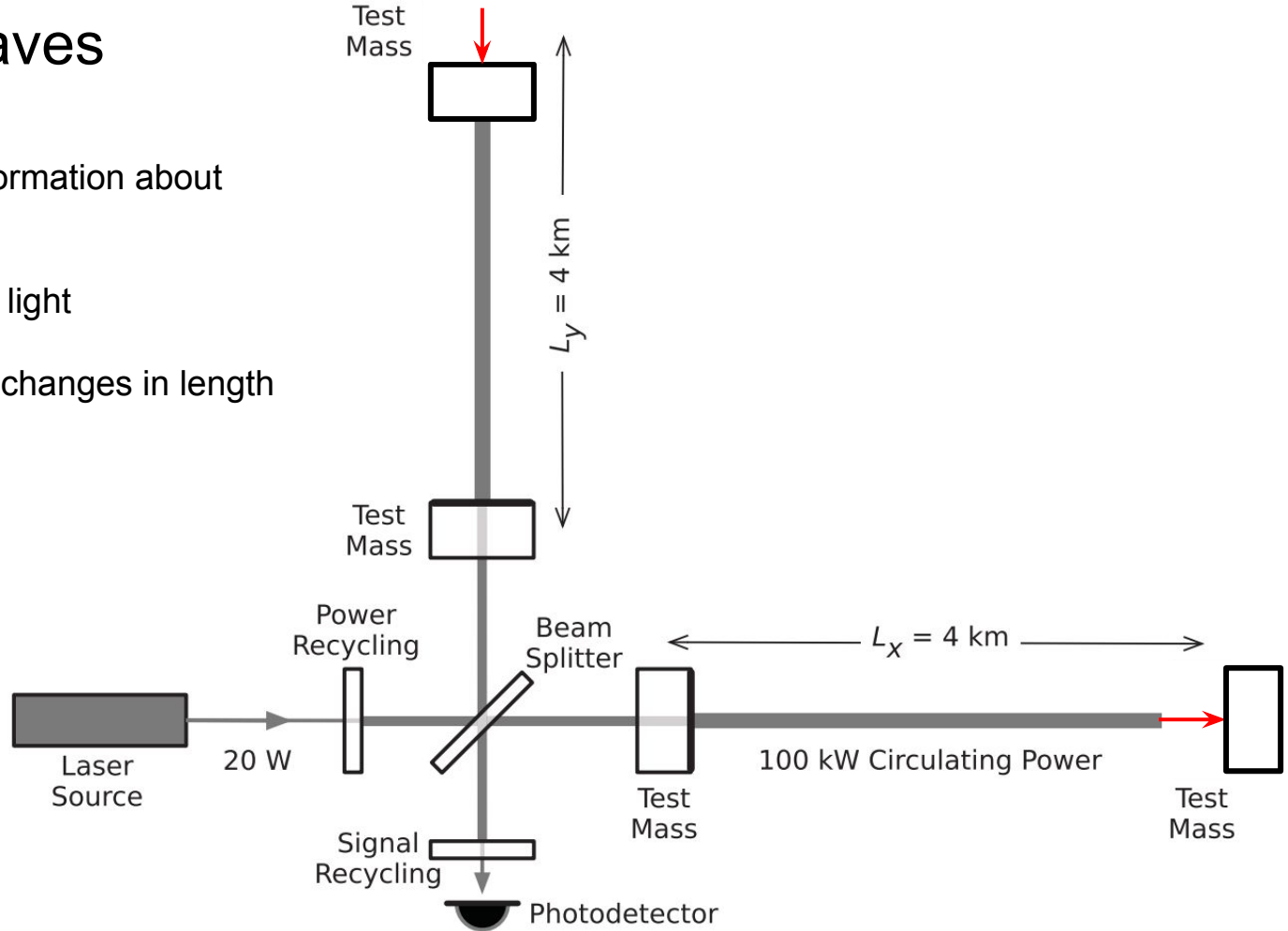
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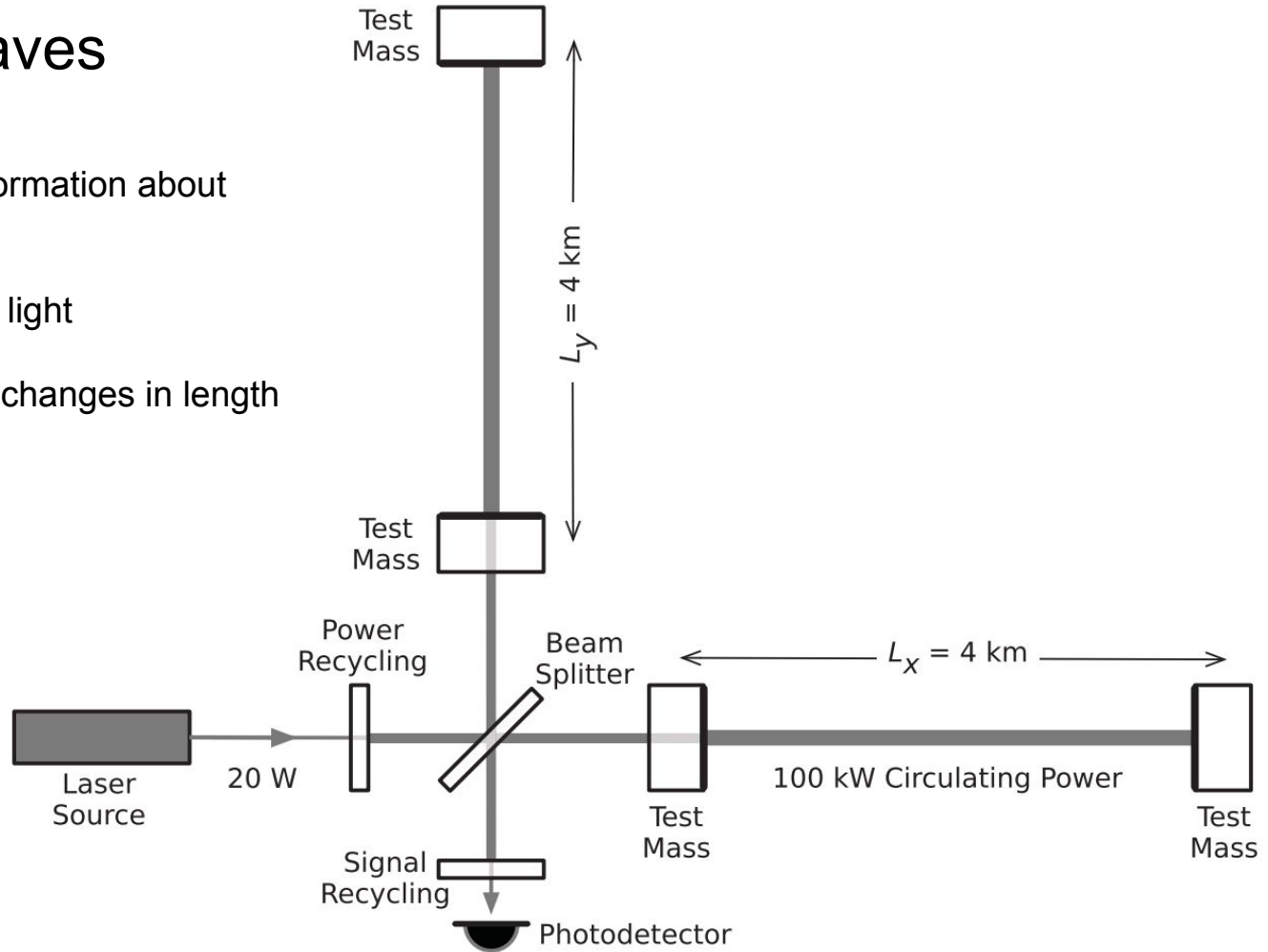
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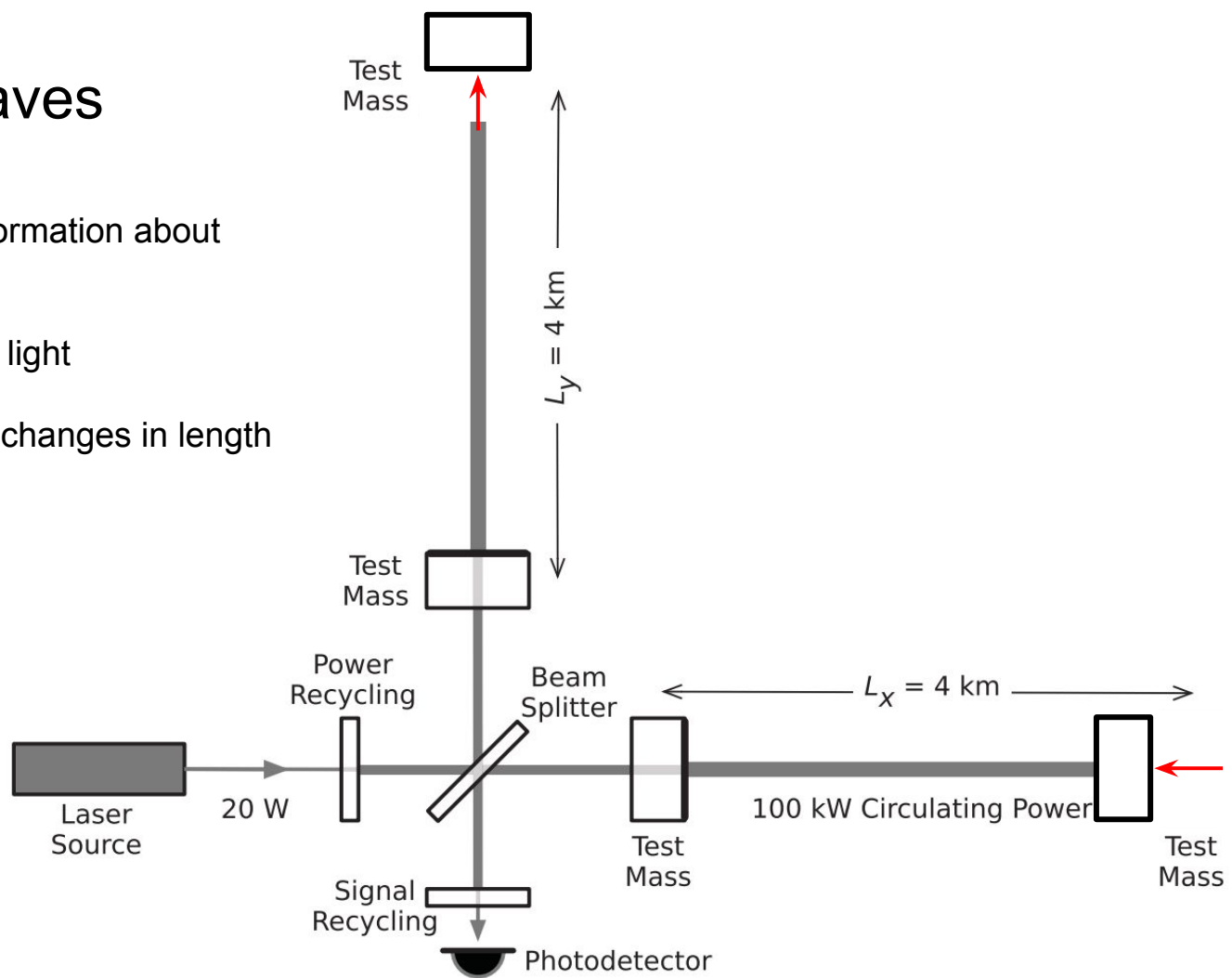
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Introduction:

Current

Detectors

Next time

Astrophysical Sources of Gravitational Waves

- Why we use big objects in space
- More about the types of big objects we use, where they come from, what happens to them
- How these things are connected to the rest of the universe

Suggested Reading

- *Black Holes and Time Warps*. Kip S Thorne.
- *The Universe in a Nutshell*. Stephen Hawking.
- *Was Einstein Right?: Putting General Relativity to the Test*. Cliff Will