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Astrophysics at the frontier: the search for gravitational waves

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***ASTROPHYSICS at the FRONTIER:
the search for gravitational waves***

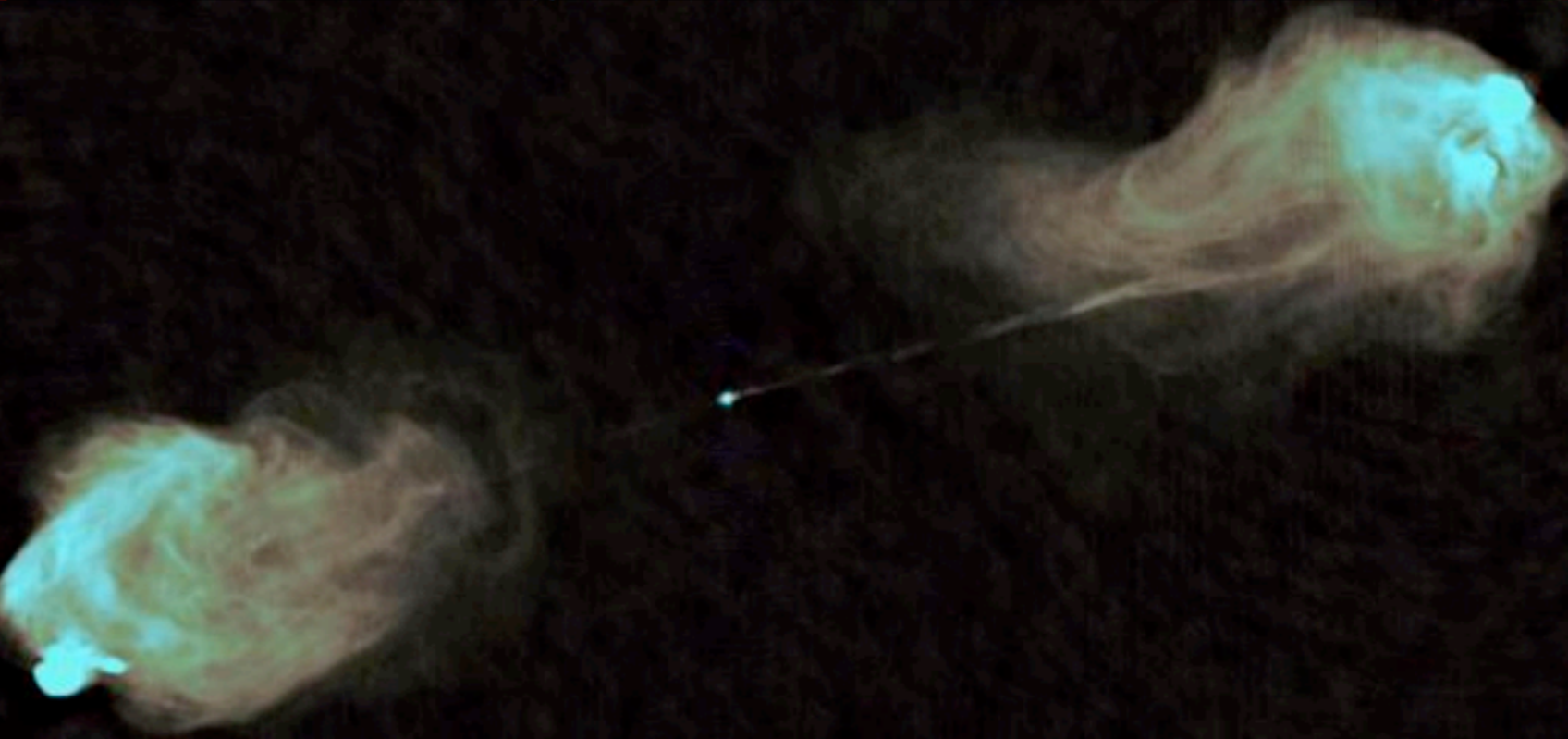
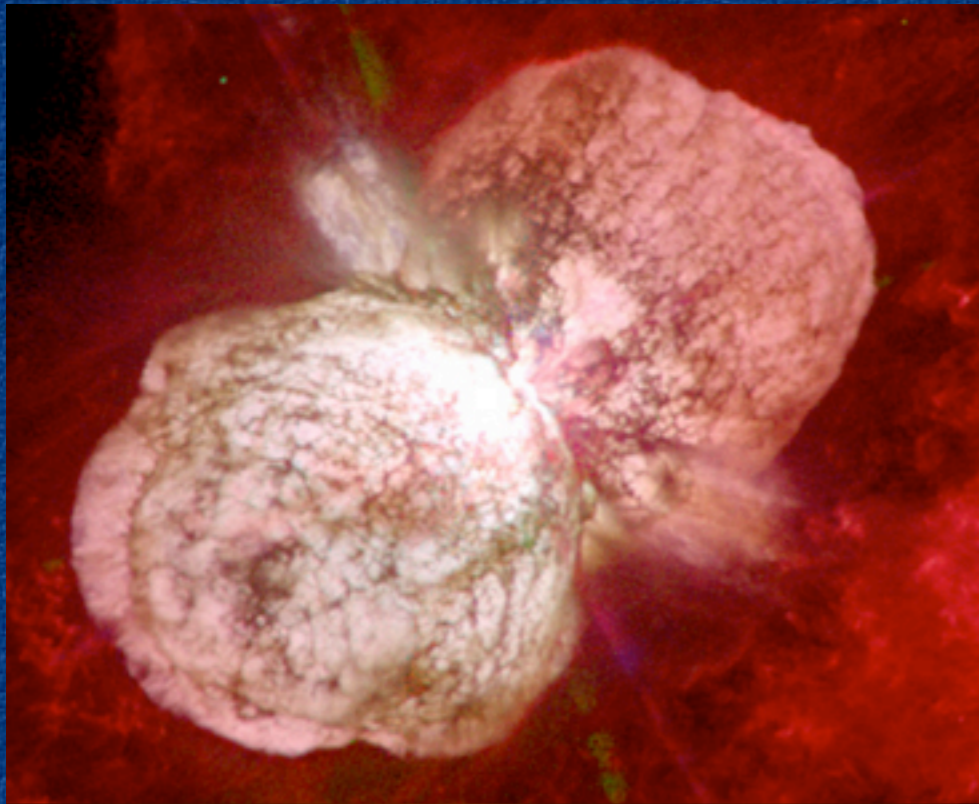
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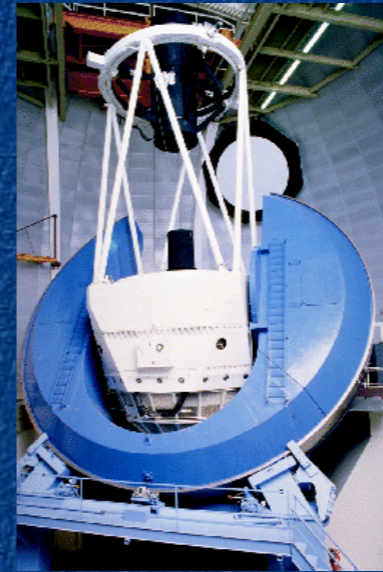
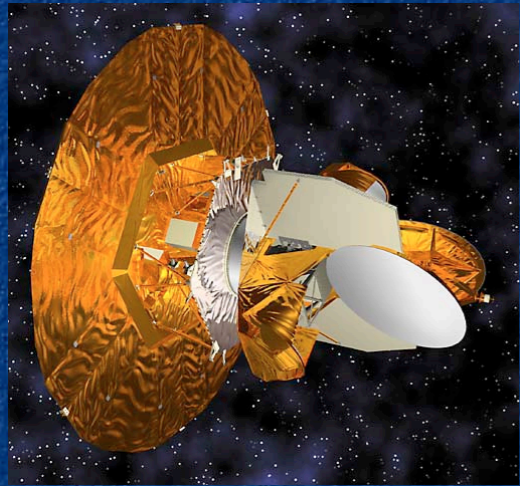
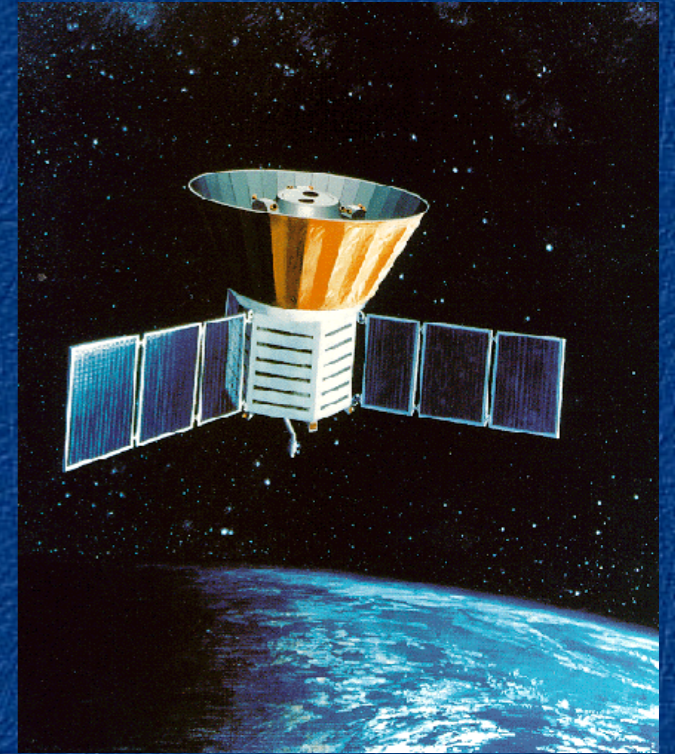
**University Briefing
Weber State University
28 November 2006**

The Cosmos as We Know It...



- LIGHT has been our messenger from the Universe.

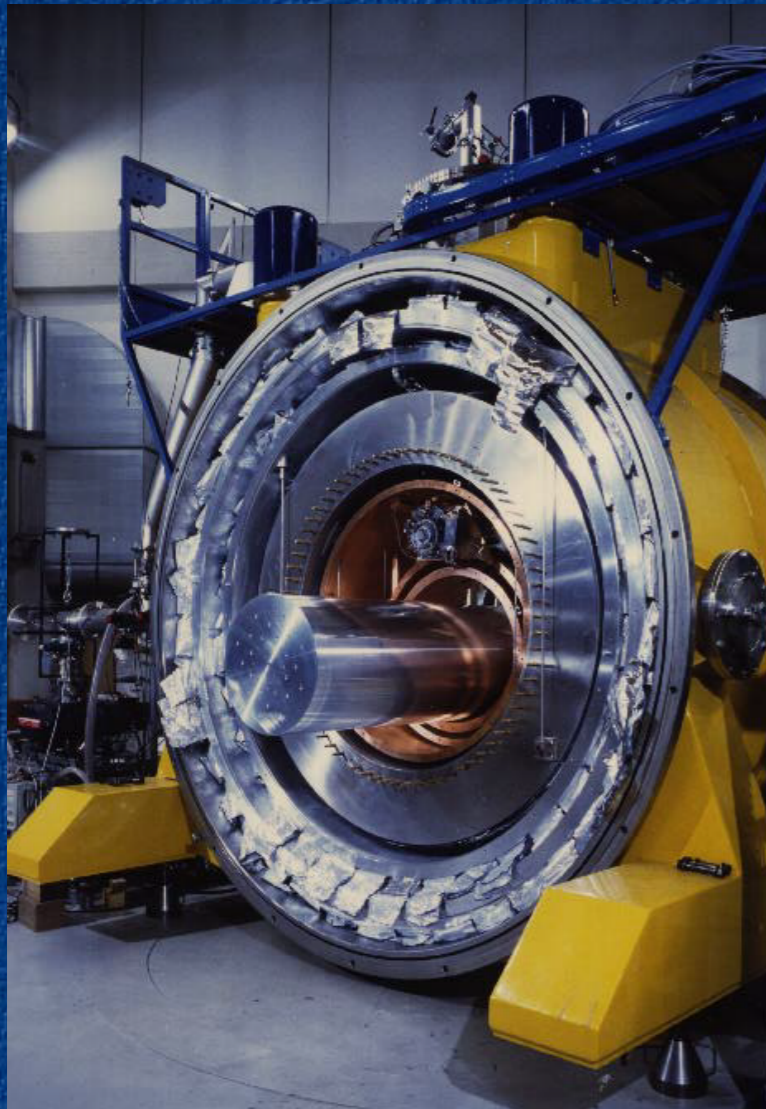
Our Eyes



- Light has many forms (visible, infrared, radio, x-ray,...) and we have a myriad of instruments to detect it.

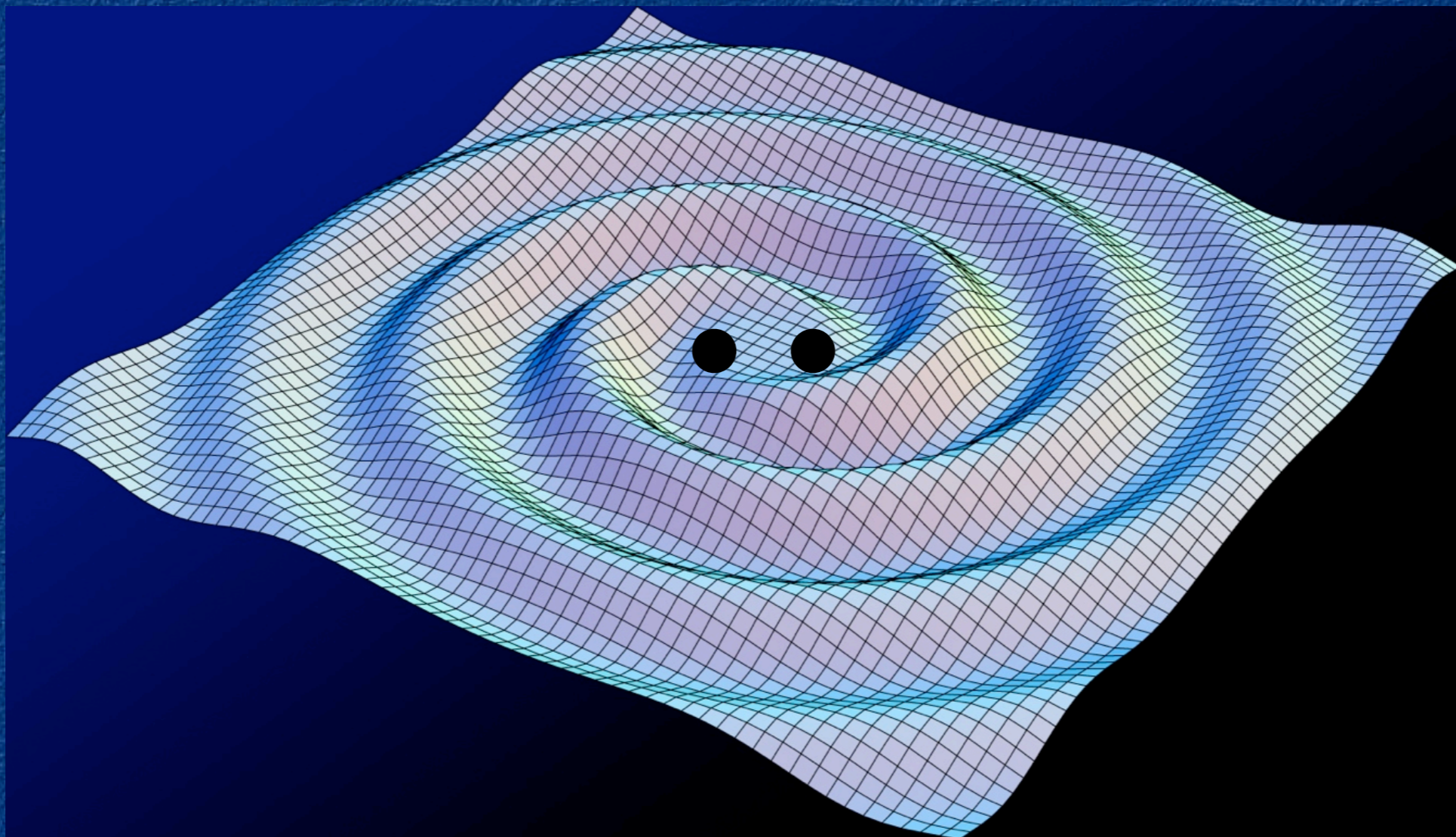
A New Kind of Astronomy

- Here at the start of the 21st Century we are looking at the Cosmos in a fundamentally new way
- Not with **light**, but with **gravity**



What are gravitational waves?

- Einstein taught us that space and time were a single entity that forms the underlying fabric of the Cosmos
- **Gravitational waves** are ripples in the fabric of spacetime which propagate through the Universe



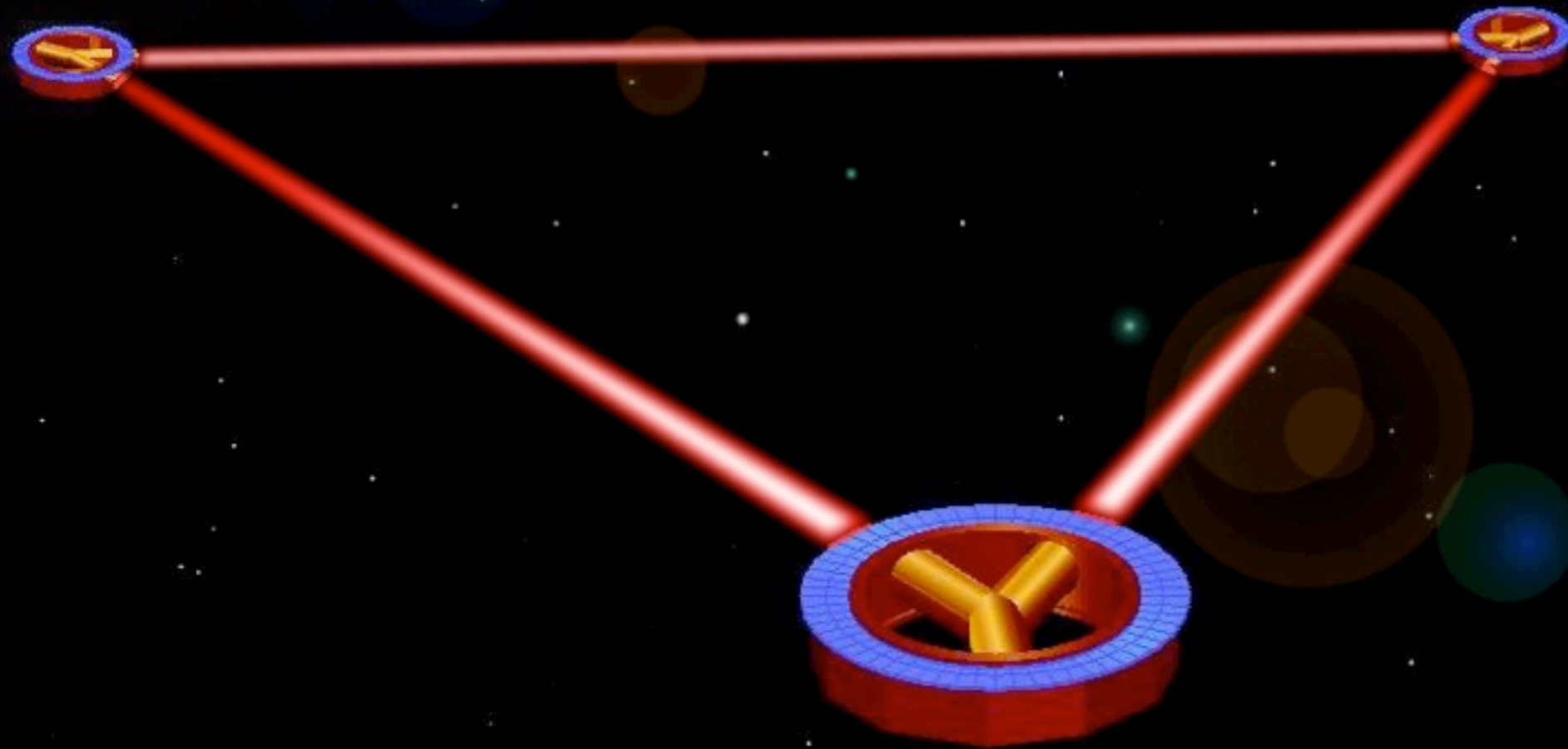
- RESONANT
- INTERFEROMETRIC

●●● LISA



THE WORLD GRAVITATIONAL WAVE DETECTOR NETWORK

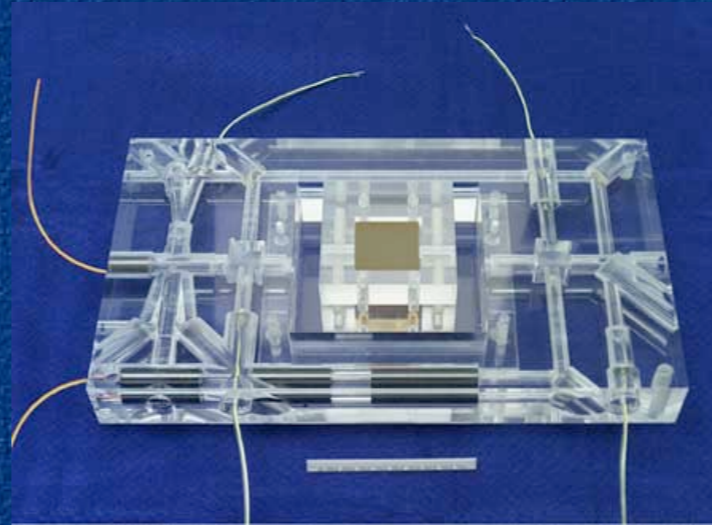
- LISA (joint NASA/ESA mission)
- Launch ~2014
- Baseline: 5 million kilometers



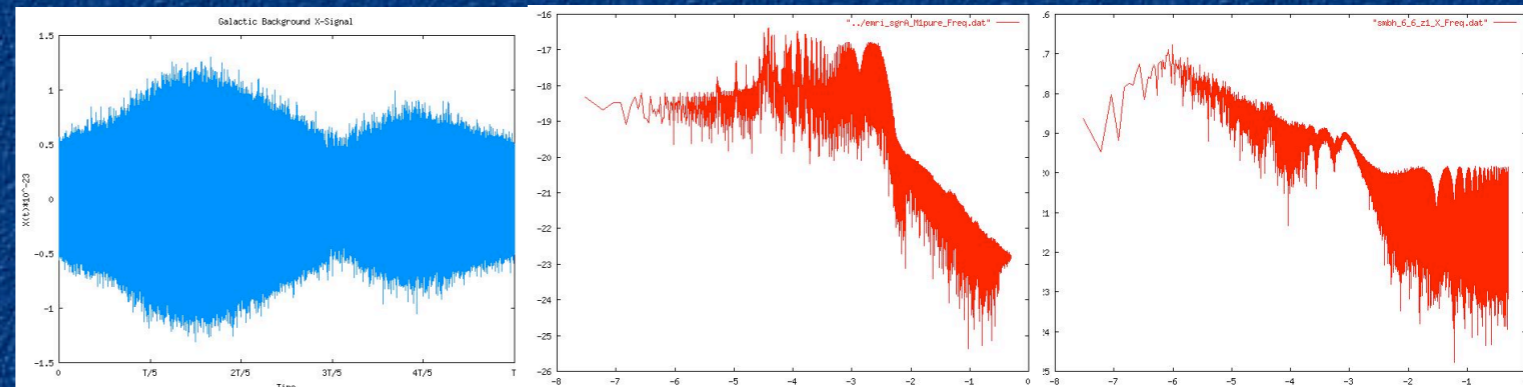
Foundations of GW Astronomy

- Gravitational wave astronomy is **interdisciplinary**, and has three main thrusts:

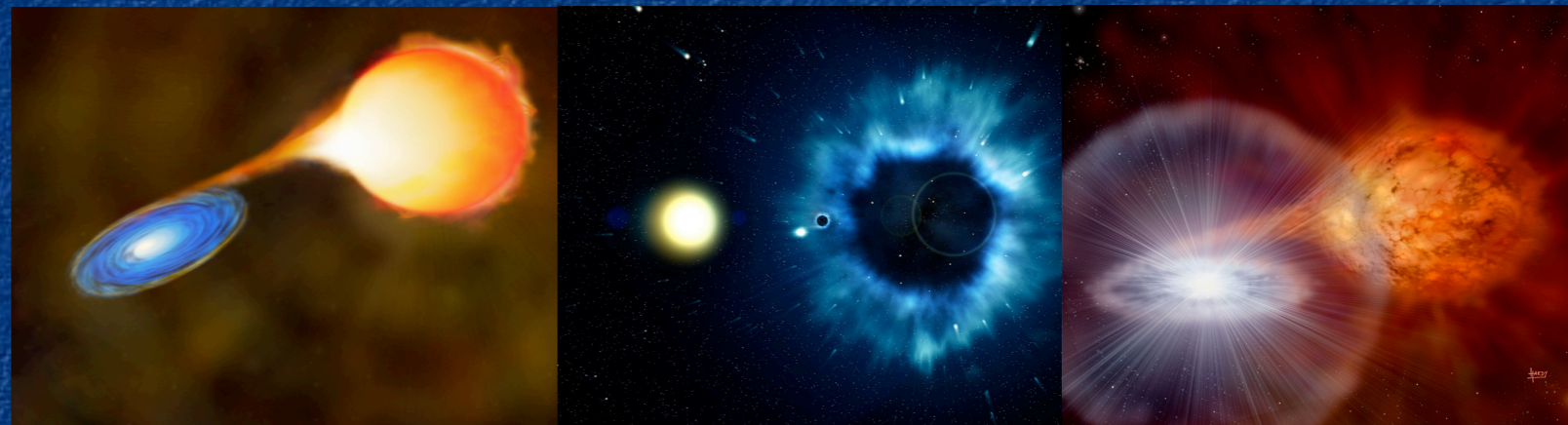
- **TECHNOLOGY**



- **SCIENCE ANALYSIS**
(data analysis)



- **ASTROPHYSICS & GRAVITATIONAL SCIENCE**



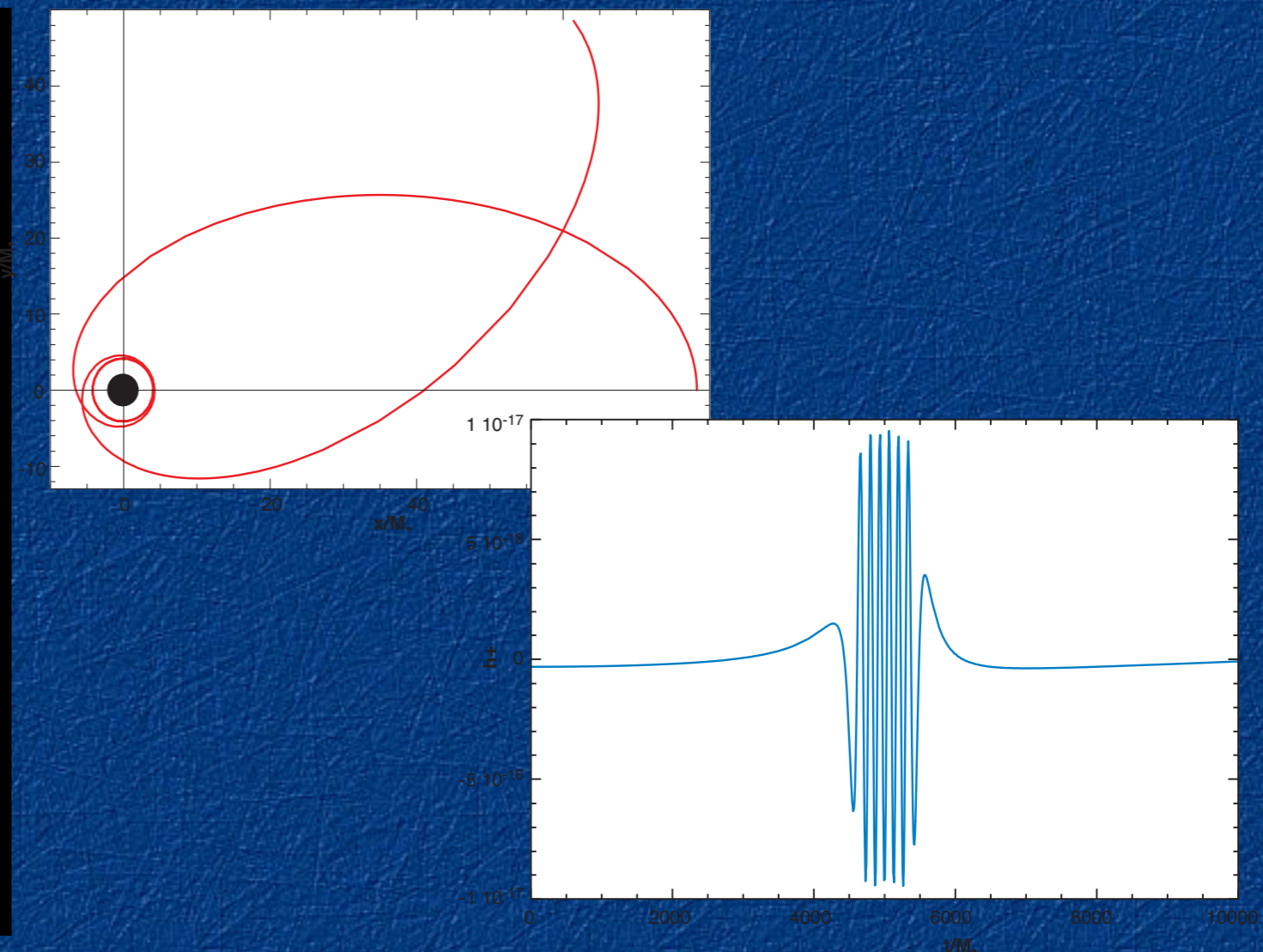
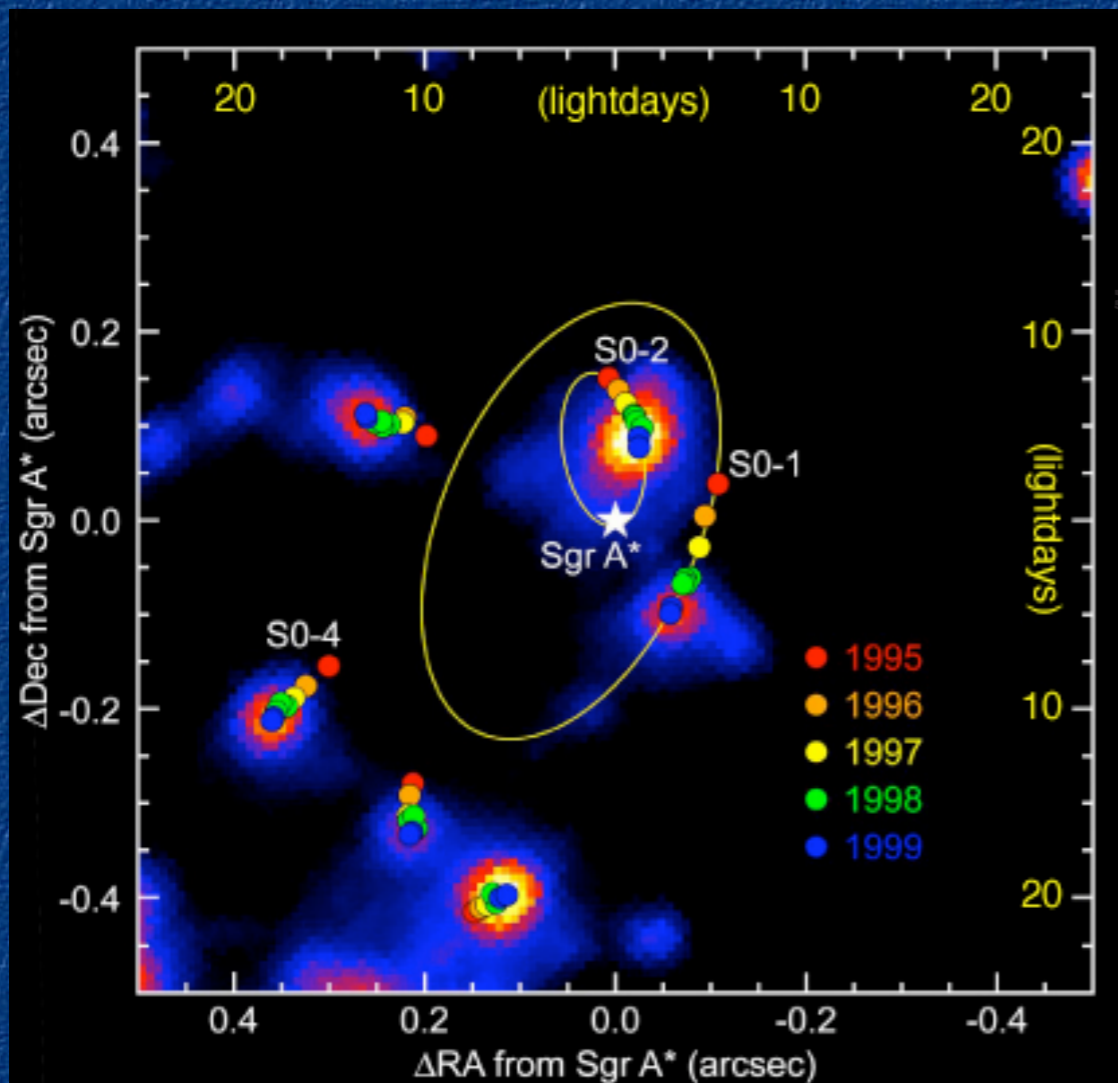
Flowdown from GW Astronomy

- **TECHNOLOGY**
 - GW detectors require **advanced optics**
 - GW detectors require **advanced laser systems**
 - GW detectors require **advanced materials**
 - GW detectors require **advanced control systems**
- **SCIENCE ANALYSIS** (data analysis)
 - GW science requires **advanced signal processing**
 - GW science requires **high performance computing**
 - GW science requires **environmental monitoring**

Vignette 1: Small Stars & Black Holes

with Marc Freitag (IoA, Cambridge) & Clovis Hopman (Leiden)

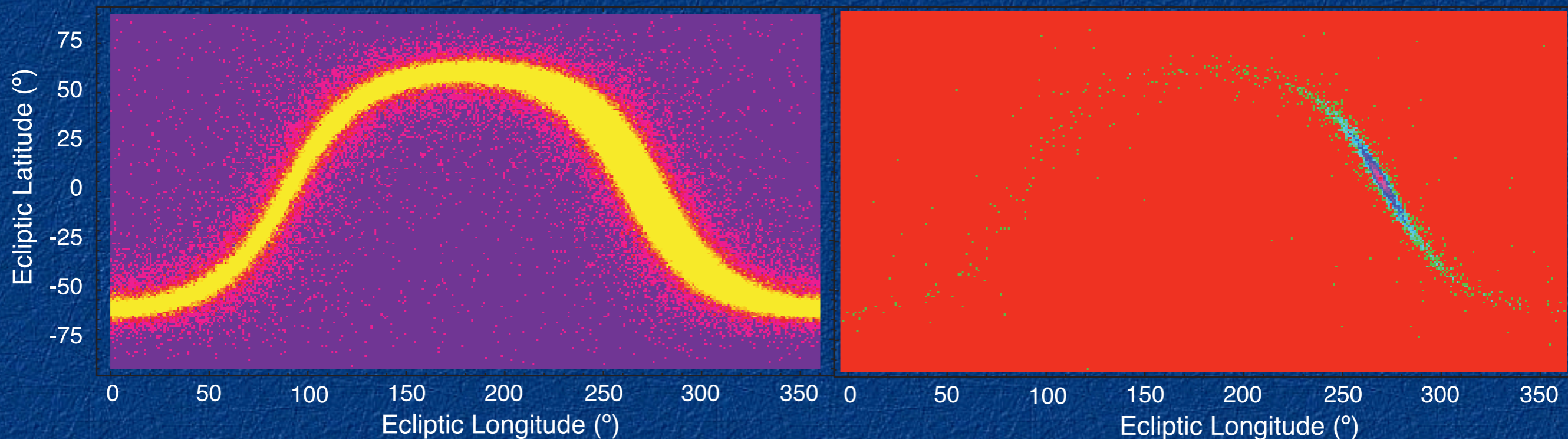
- Compact stellar mass objects sometimes get captured by massive galactic black holes
- The inspiral encodes a map of the black hole spacetime in the gravitational waves



Vignette 2: The Shape of the Galaxy

with Matt Benacquista (UT-Brownsville) & Brett Taylor (Radford)

- LISA will see compact binary stars everywhere in the Milky Way galaxy
- The locations of these stars encodes a map of the shape and history of stellar evolution in the galaxy
- Galactic modeling & science analysis together



My Future at Weber State

- **SCIENCE**
 - Galactic modeling
 - Multi-messenger astronomy: working with gravitational waves and light together
- **G.R.A.I.L.** (Gravitational-wave Resource And Information Library)
- **GRAVITATIONAL WAVE TEXTBOOK**
- **MINIONS** (student research)
 - I have a box of projects that need done
 - Undergraduates can work in GW astronomy, and publish in mainstream journals [Zaleski & Larson ~2007; Larson, Rubbo, Zaleski & Larson 2006; Rubbo, Larson, Larson & Zaleski 2006; Hiscock, Larson, Rutzahn & Kulick 2000; Clark, Hiscock & Larson 1999]

Challenges for GW Astronomy

- **COMMUNITY BUILDING**
 - GW astronomy is very interdisciplinary
 - Needs to be better communication between gravitational theory, experimental physicists, and astrophysicists.

- **BRAIN POWER**
 - The GW astronomy effort is extremely understaffed
 - Need to have more professors in the field
 - Need to train more young people in the field
 - Need to retain young people in the field

G.R.A.I.L.

- Proposed to NASA IDEAS
 - Develop materials to use in college classrooms to teach about gravitational wave astronomy
 - Audio Waveform Library
- **Collaboration between 19 Institutions (so far)**
 - Weber State (Larson – PI)
 - Weber State (Johnston)
 - Mankato (Tom Brown)
 - Franklin & Marshall (Andrea Lommen)
 - Colorado College (Patti Purdue)
 - Youngstown State (Pat Durrell)
 - U Maryland (Cole Miller)
 - Salish-Kootenai College (Tim Olson)
 - UT Brownsville (Matt Benacquista)
 - Penn State (Sam Finn)
 - SUNY-Geneseo (Savi Iyer)
 - Montana State (Bill Hiscock)
 - Pomona College (Tom Moore)
 - Radford University (Rhett Herman)
 - St. Louis University (Greg Comer)
 - Truckee Meadows CC (Dan Loran)
 - Highline CC (Gregory Reinemer)
 - U Central Florida (Hanno Brueckner)
 - Washington State (Sukanta Bose)
 - East Tennessee State (Ricco Ignace)