

Multi-messenger Astronomy: Expanding Astronomy's "Senses"

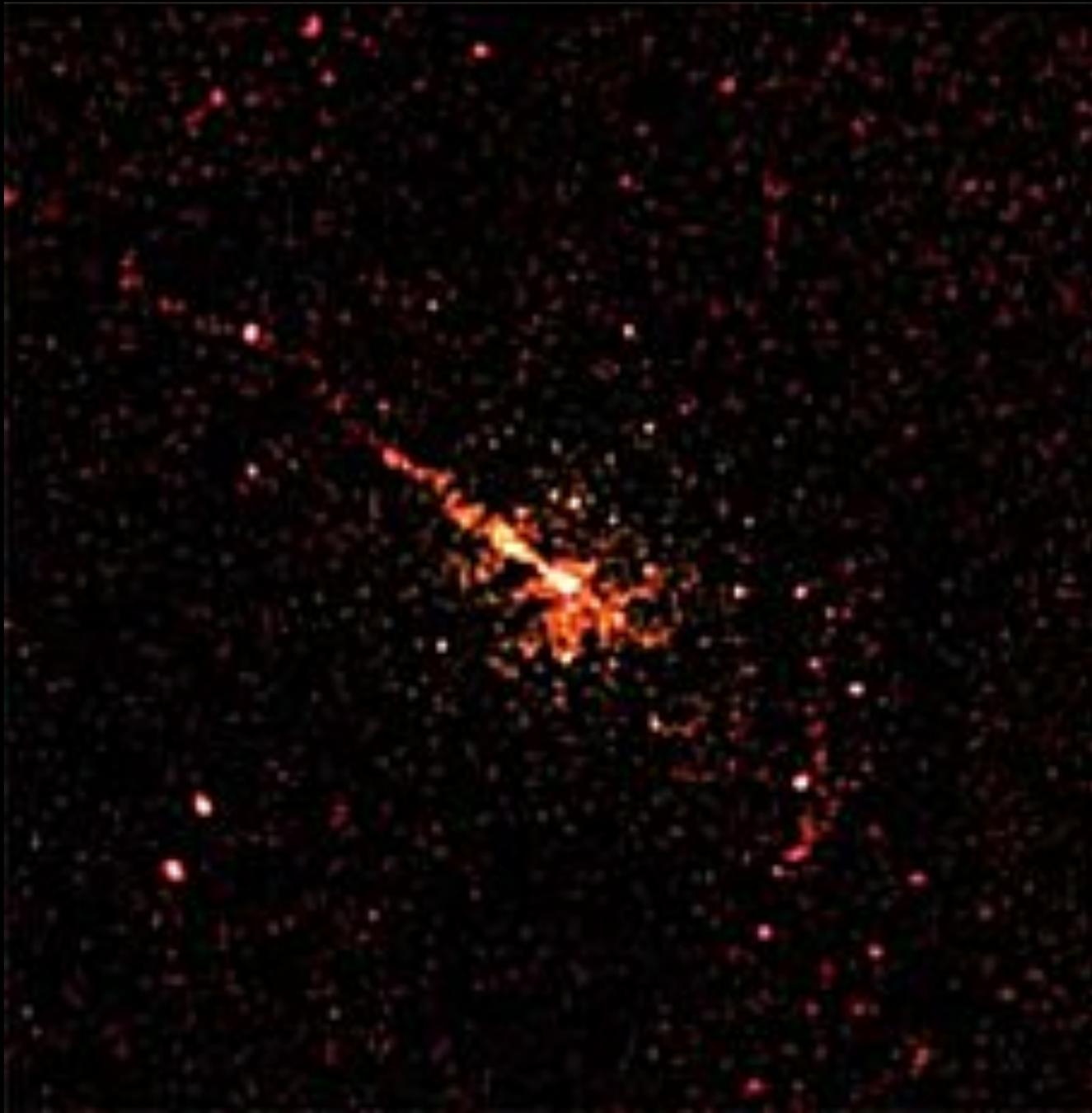
Amber L. Stuver

LIGO Livingston Observatory



Examples of Astronomy Observations
Made with Different Kinds of Light...

X-ray



Ultraviolet



Visible Light



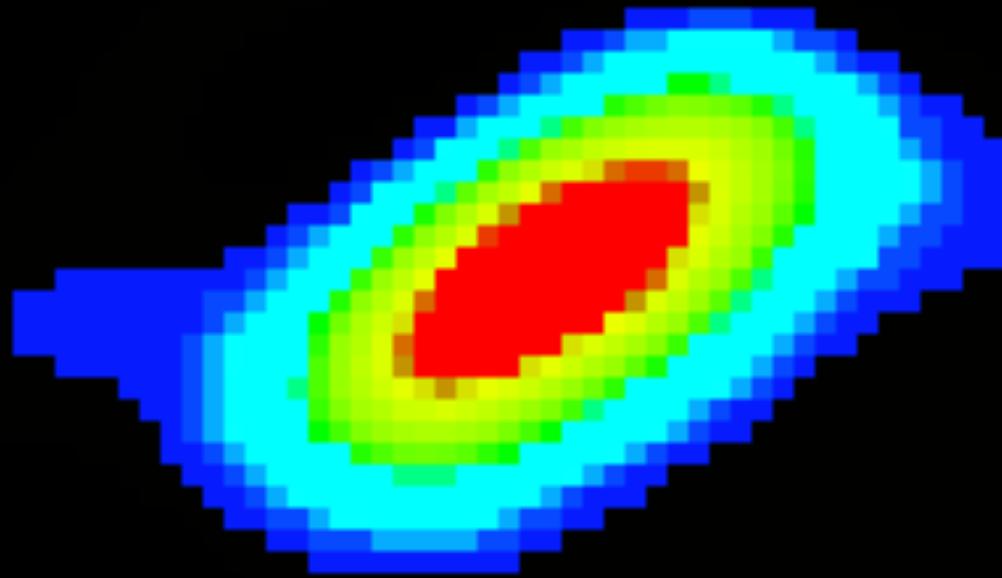
Near-Infrared



Mid-Infrared



Far-Infrared

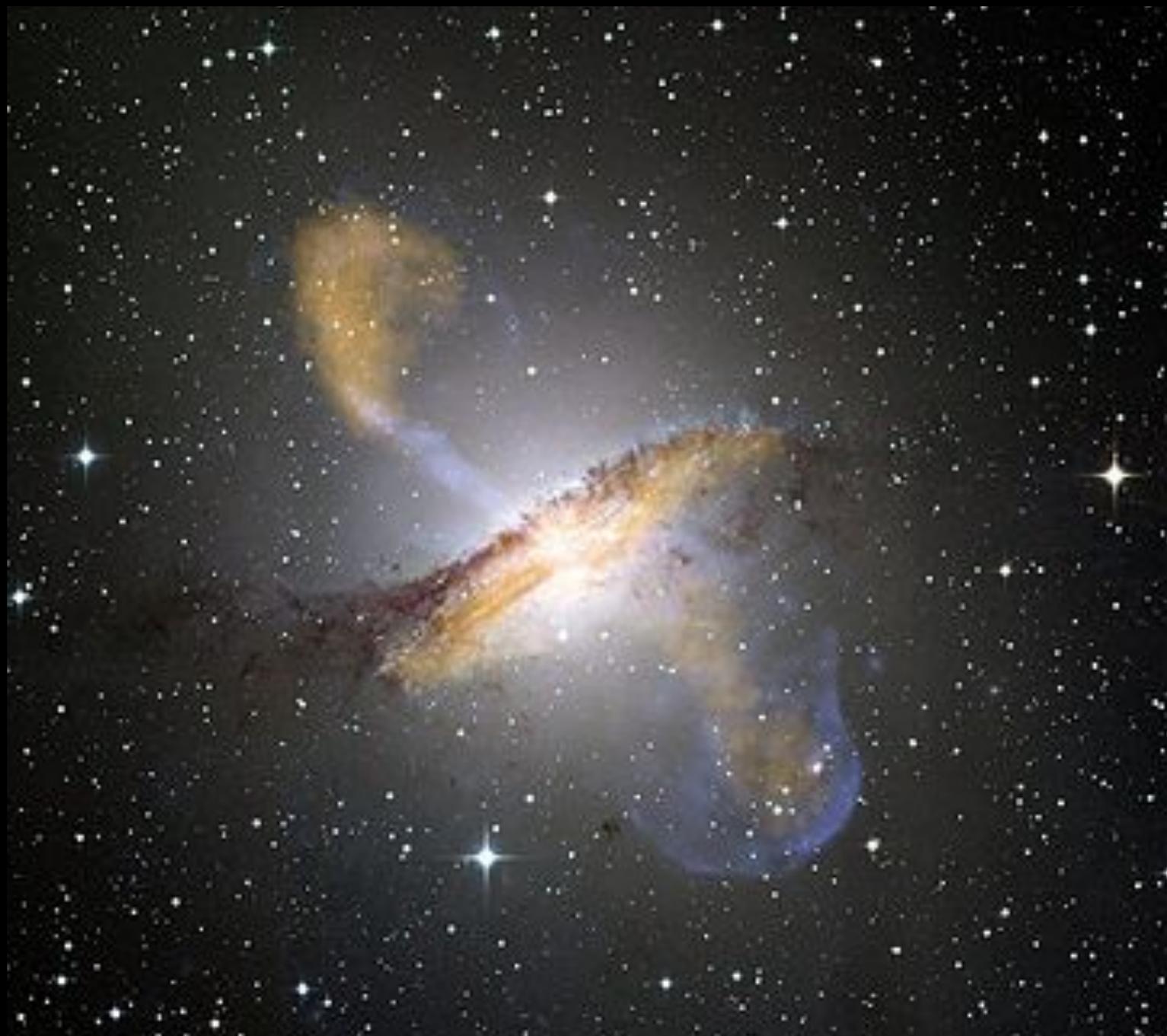


Radio



These are all observations of the same object: the galaxy Centaurus A.

When all of these observations are combined, a more complete picture of this galaxy forms...



Visible Light



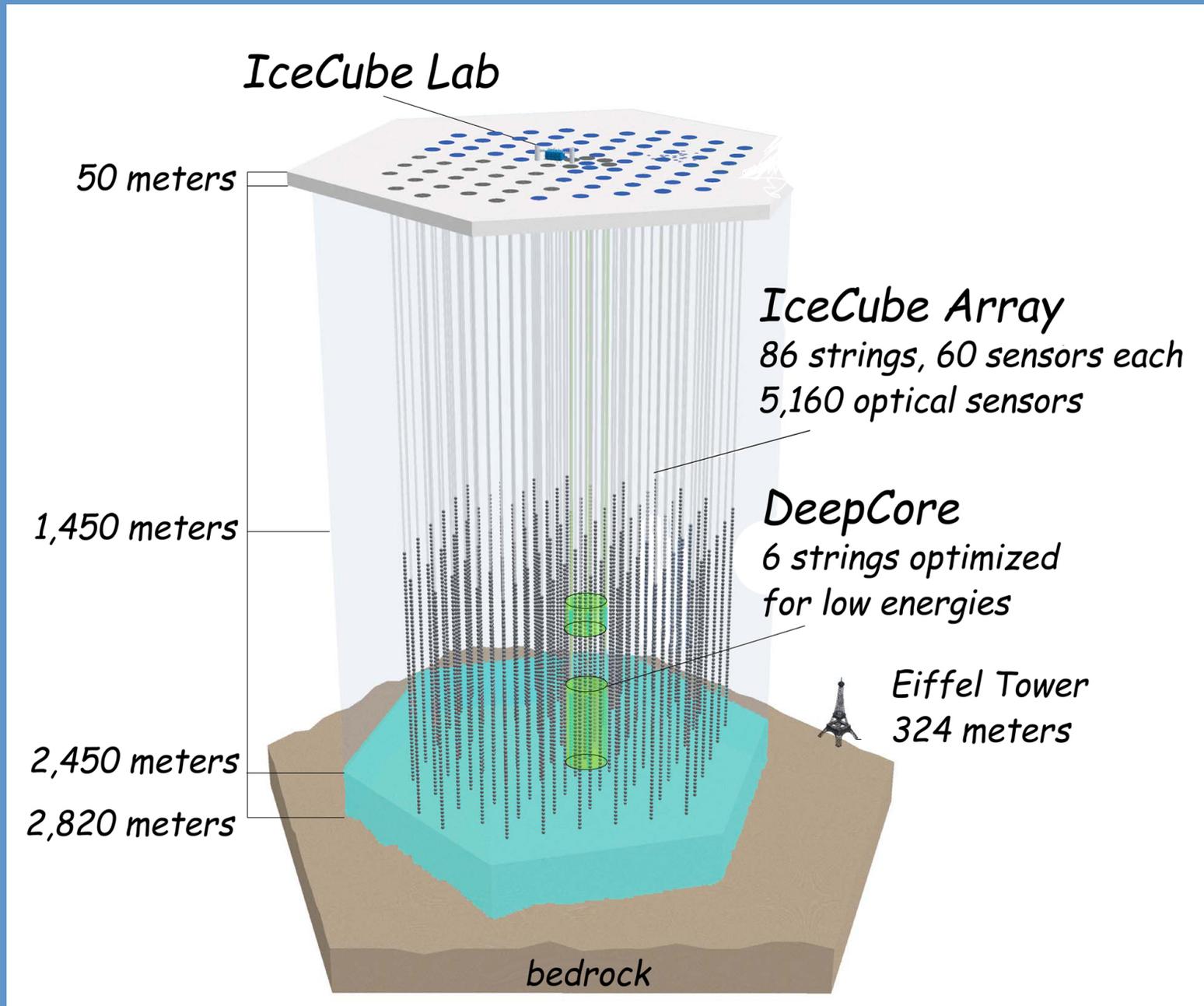
What would music sound like if
limited to specific octaves?



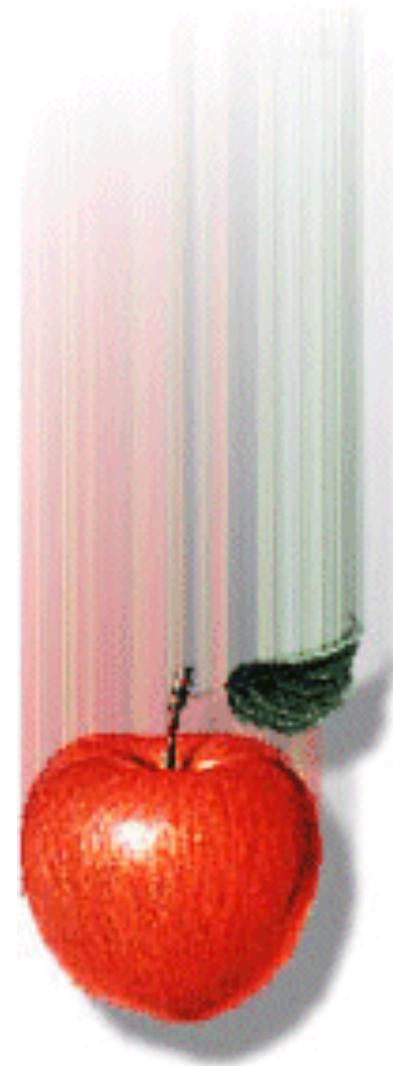
Neutrinos

- Are essentially massless particles, without charge, and travel at the “speed of light”
- So weakly interact with matter they can travel through it unchanged
- Are produced by nuclear reactions including those in stars
- The detection of neutrinos has already led to discoveries about supernovas (more on this later).

IceCube Neutrino Observatory

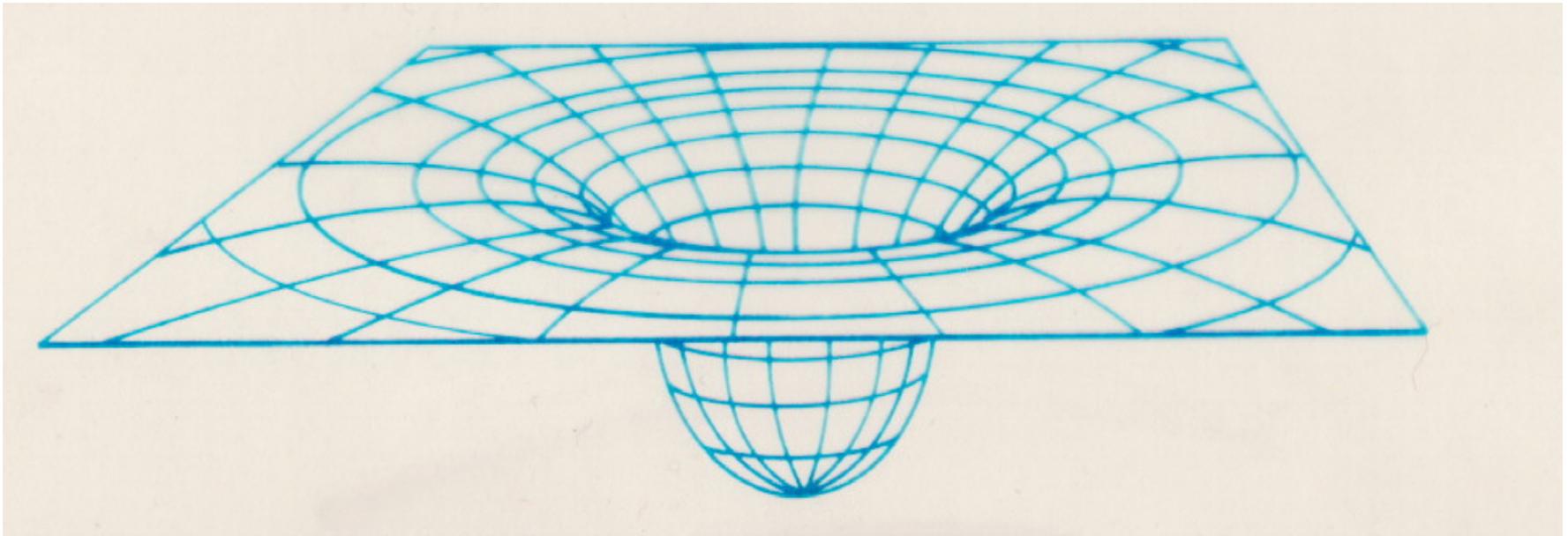


Newton's Gravity



Einstein's Gravity

Nothing in the universe can travel faster than the speed of light, including information on the distribution of mass.



The LIGO Observatories



← Livingston, Louisiana

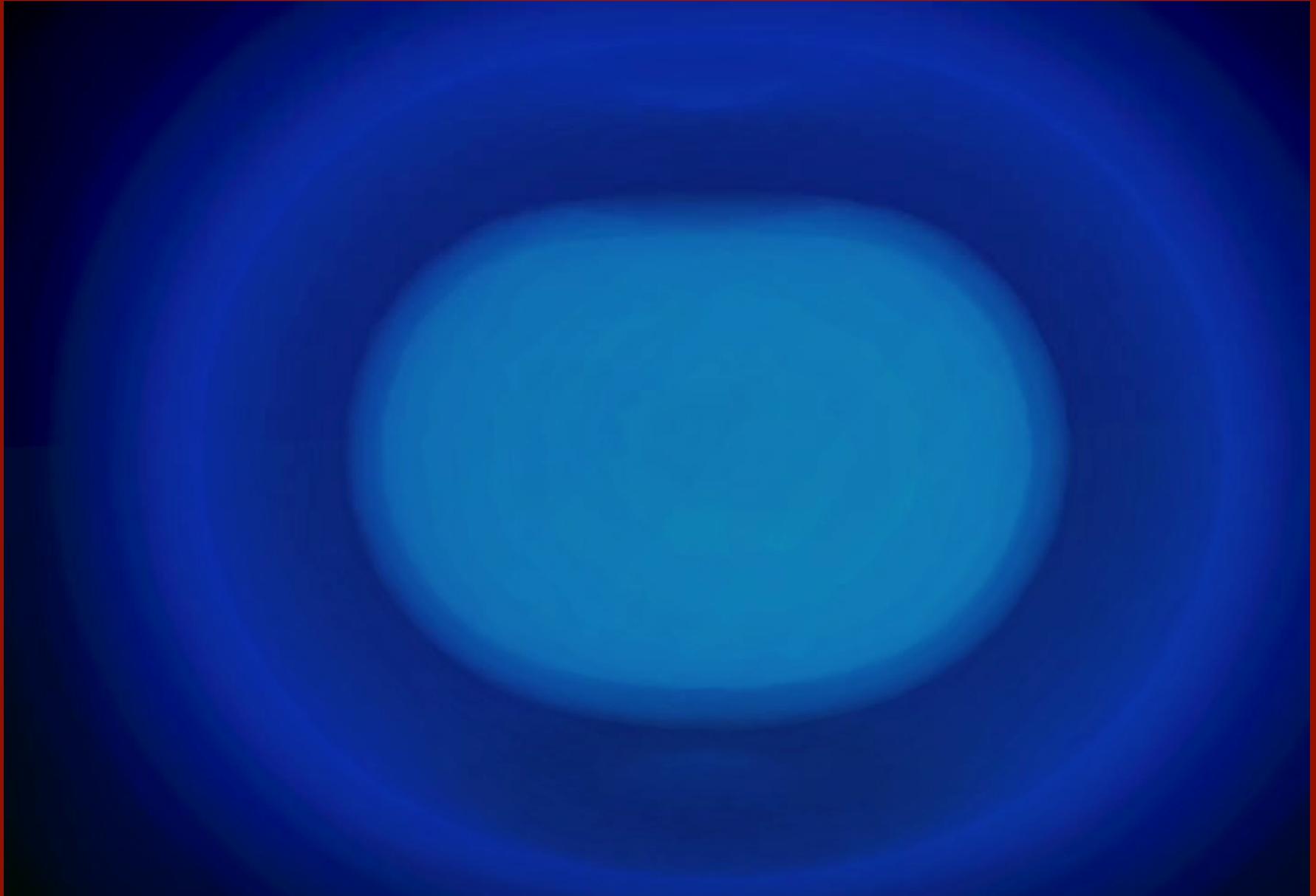


Hanford, Washington →

Gravitational-Wave Astronomy

- The physics of the system that produced the gravitational wave is encoded in the wave itself.
- The universe is transparent to gravitational waves.
- Will be able to see the universe as never before:
 - » The earliest moments of after the Big Bang
 - » Systems that are not light producing
 - » Systems that are otherwise obscured
 - » The unexpected...

Case Study: Core Collapse Supernova



Abstract

Every time humans have looked at the Universe in a new way, we have found something that was unexpected that revolutionized our understanding of the Universe. Light has been the primary tool for doing astronomy since ancient times. Only recently have other ways of looking at the Universe become available, notably neutrinos and gravitational waves. Observing the Universe with different media is a growing field of astronomy called multi-messenger astronomy. This conversation will describe how astronomy revolutionized how we see the Universe and how multi-messenger astronomy will expand our "senses" to observe the Universe in fundamentally new ways. Multi-messenger astronomy examples used will be from the experience of the LIGO gravitational wave observatories. The potential of this new field of astronomy will be discussed, but the unexpected is expected to be the most exciting!