

The Music of the Spheres

Prof. Roberto Trotta

 @R_Trotta

Credit: NASA / JPL-Caltech / SSI / Ian Regan

Imperial College
London

www.robertotrotta.com



The Planets



Imperial College
London



Gustav Holst
ca 1921

Credit: Herbert Lambert/National
Portrait Gallery



Antony Tudor, *The Planets* (1934). The Mercury scene with Sylvia Briar, Frank Staff
and Audrey Turner, Melbourne, 1947.

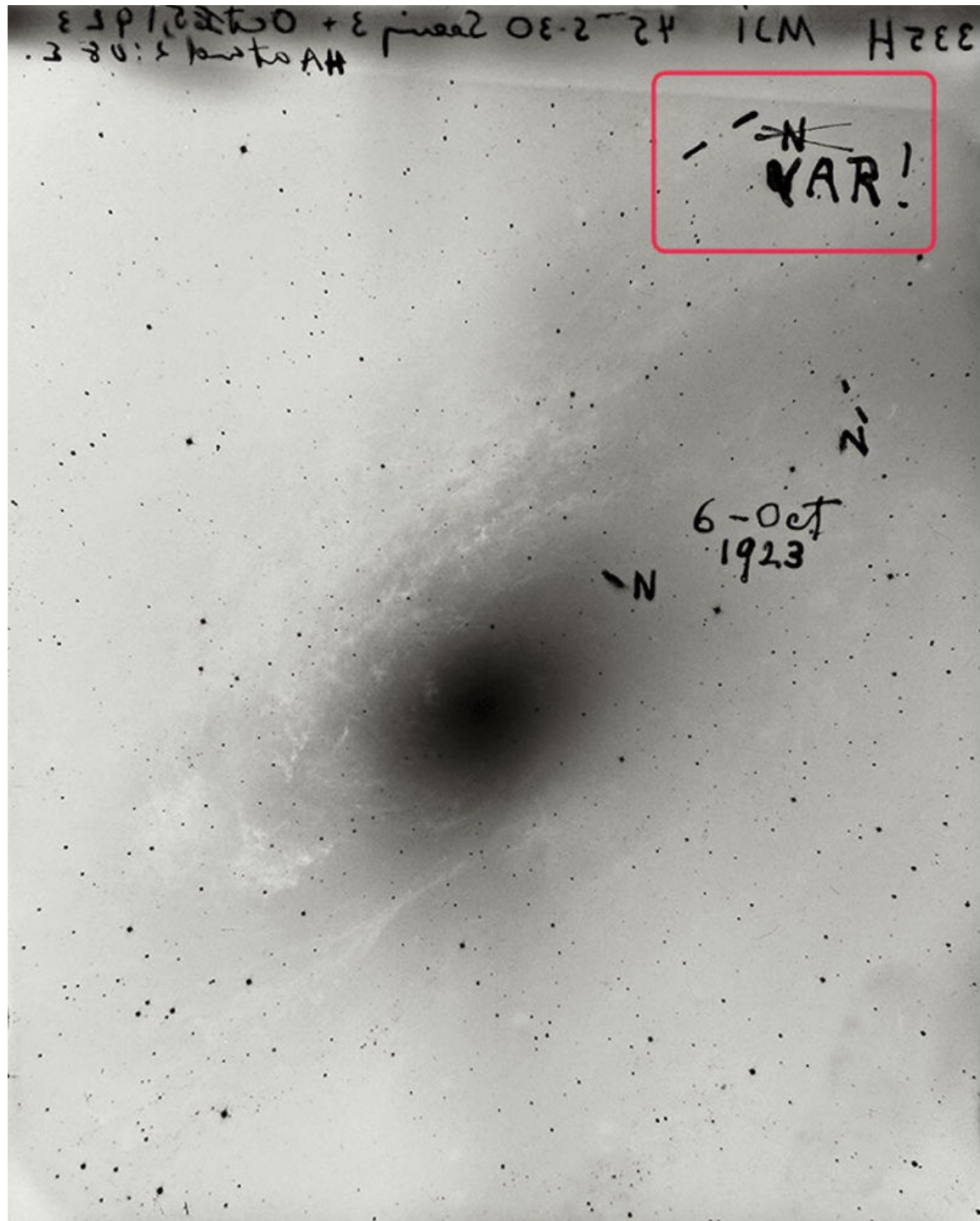
Credit: Jean Stewart/Rambert Performance Database

Music: Gustav Holst, *The Planets*, performed by the Royal Liverpool Philharmonic Orchestra, conducted by Sir Charles Mackerras.

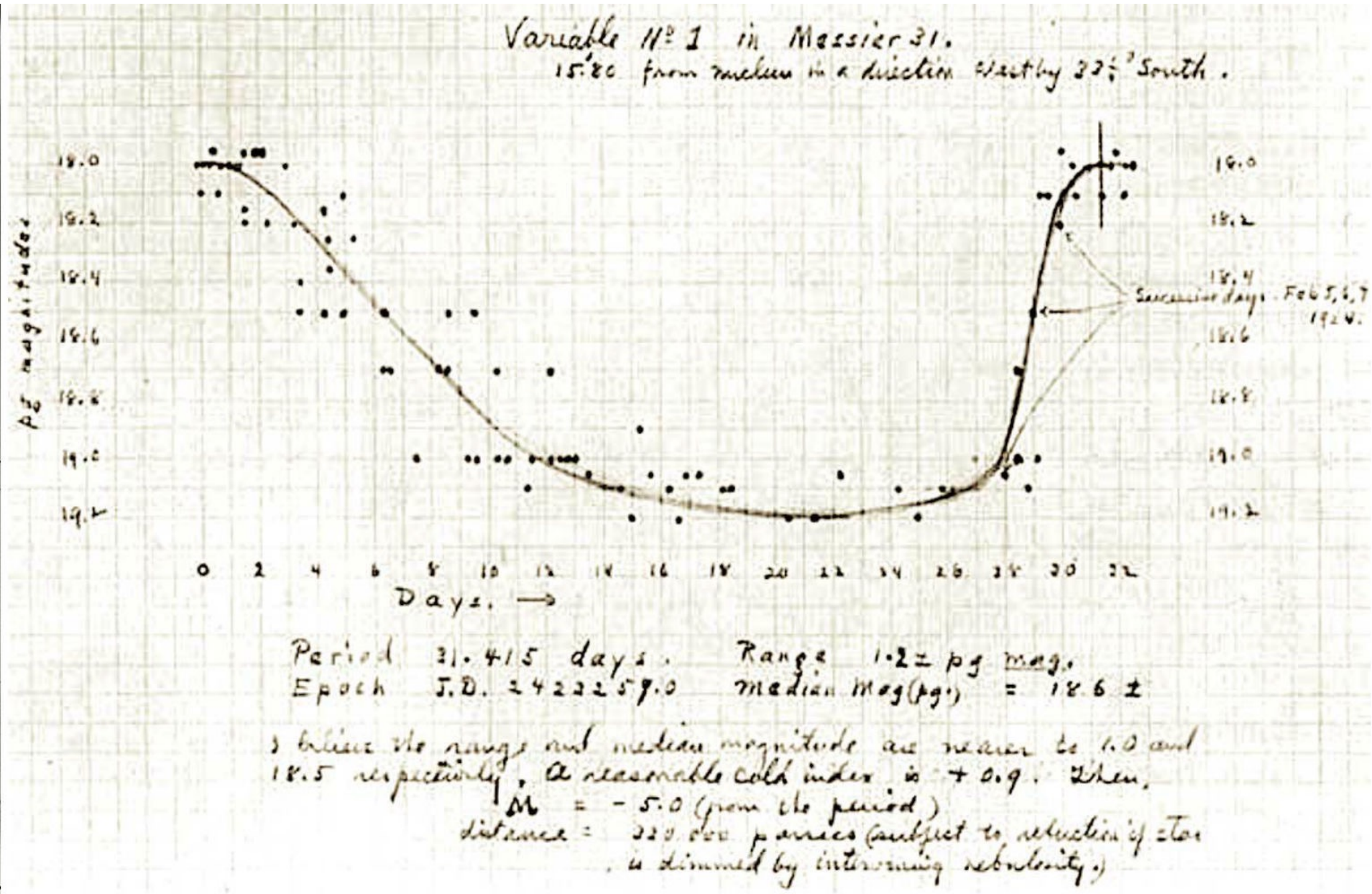
Oct 6th, 1923



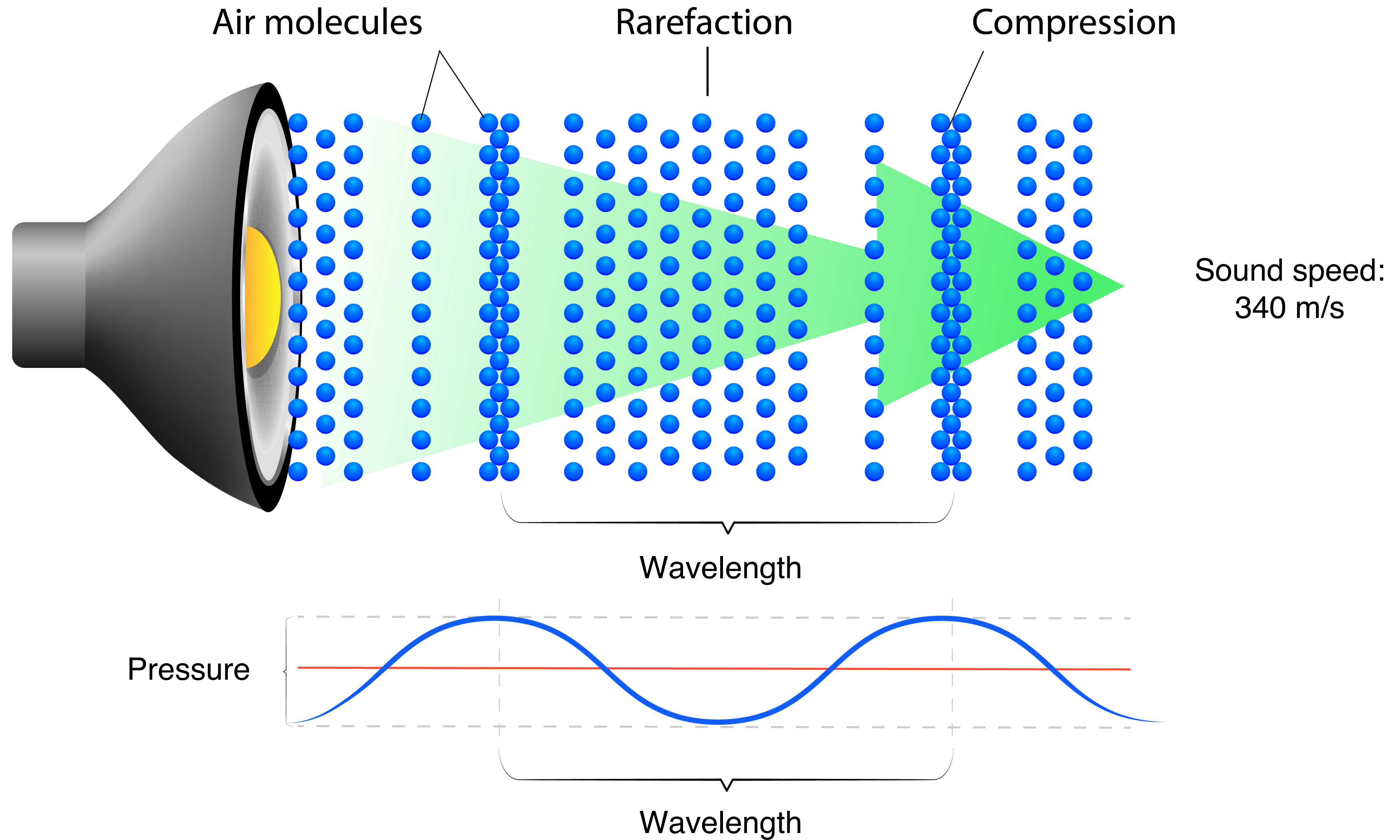
Edwin Hubble
ca 1922
Credit: Huntington Library



Credit: Carnegie Observatories



SOUND WAVES

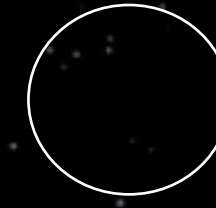


“In space, no one can hear you scream”

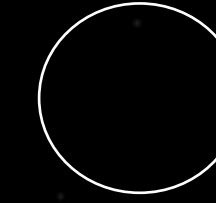
Alien (1979)



Photons (413 per cm^3)



Neutrinos (112 per cm^3)



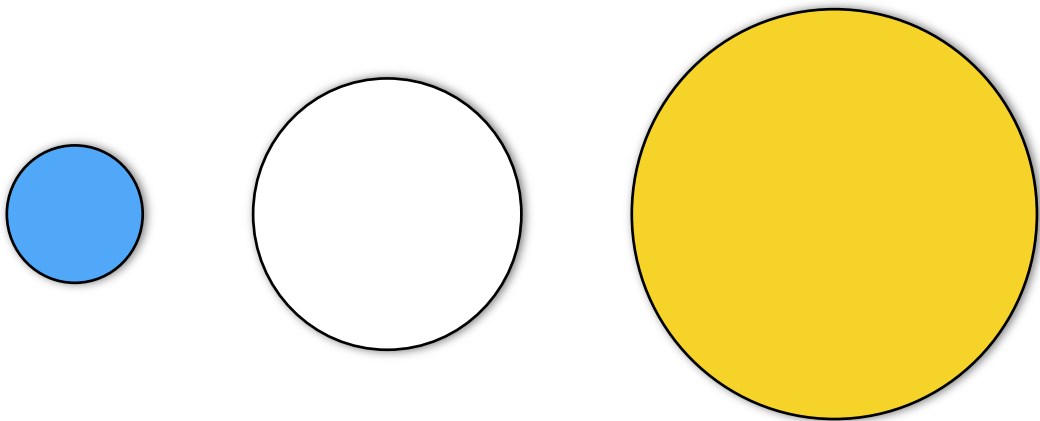
Dark matter? (0.004 per cm^3)



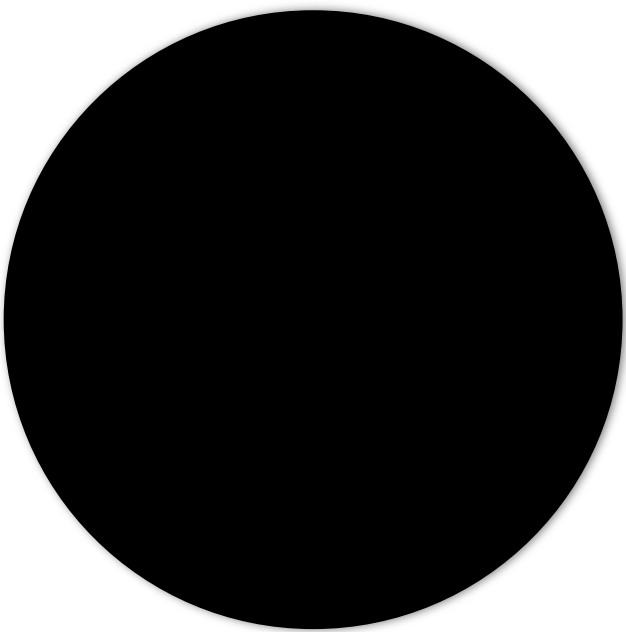
The Expanding Universe



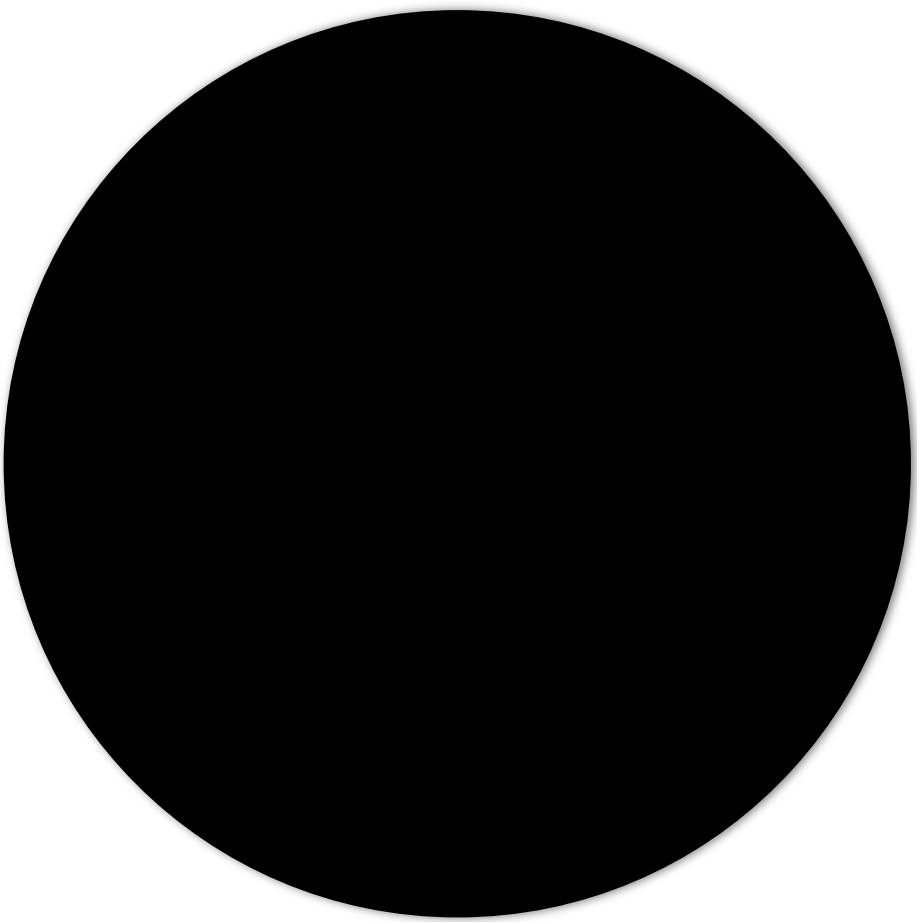
$T = 3,000\text{ K}$



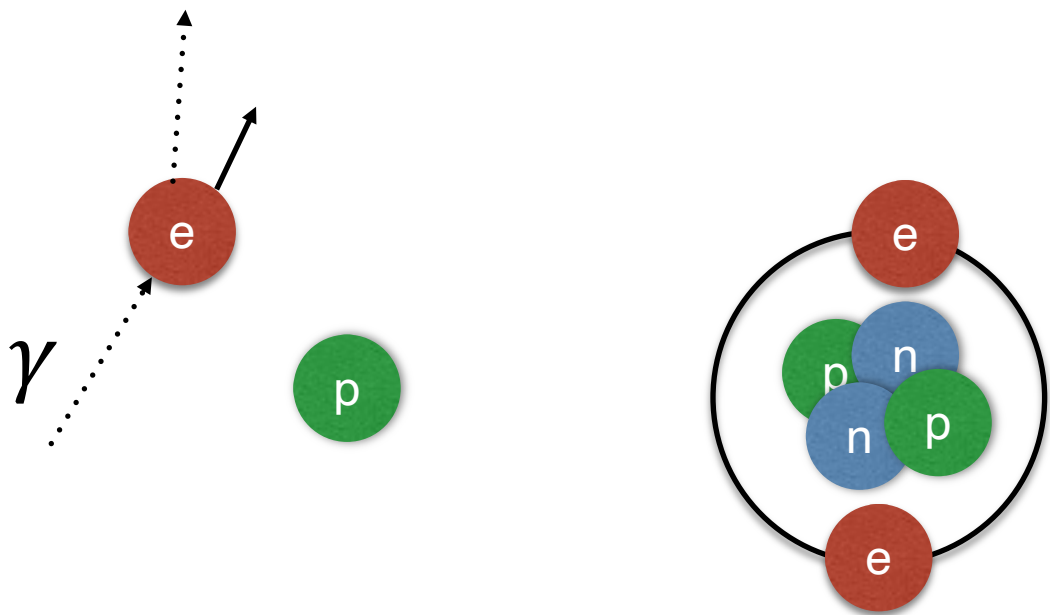
$T = 30\text{ K}$



$T = 3\text{ K}$

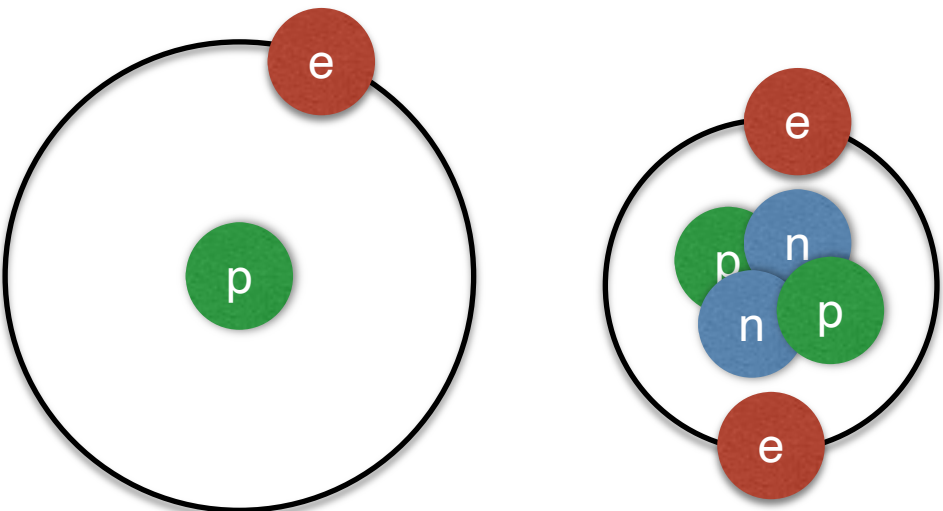


380,000 yrs



Hydrogen

Helium

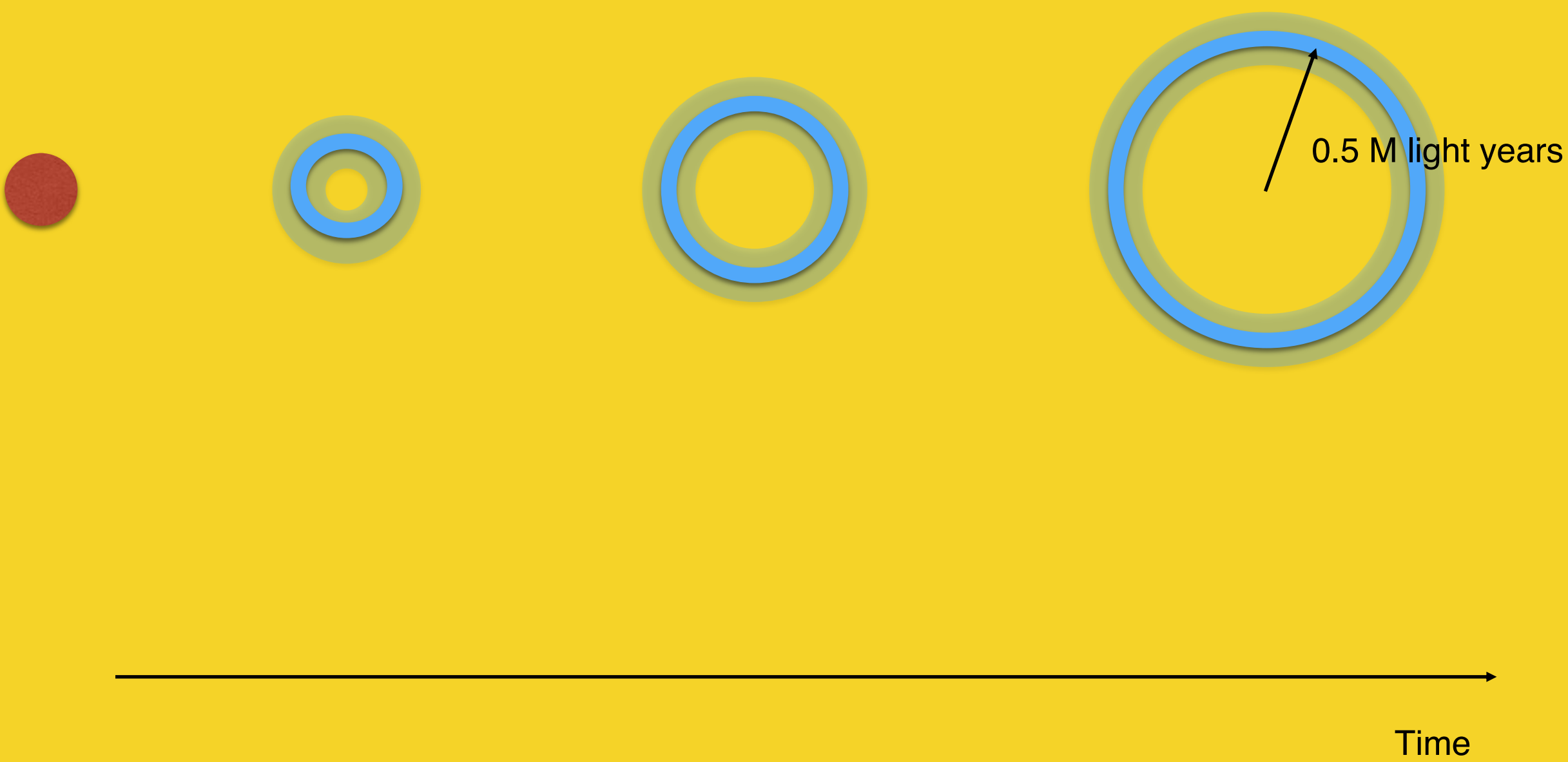


Hydrogen

Helium

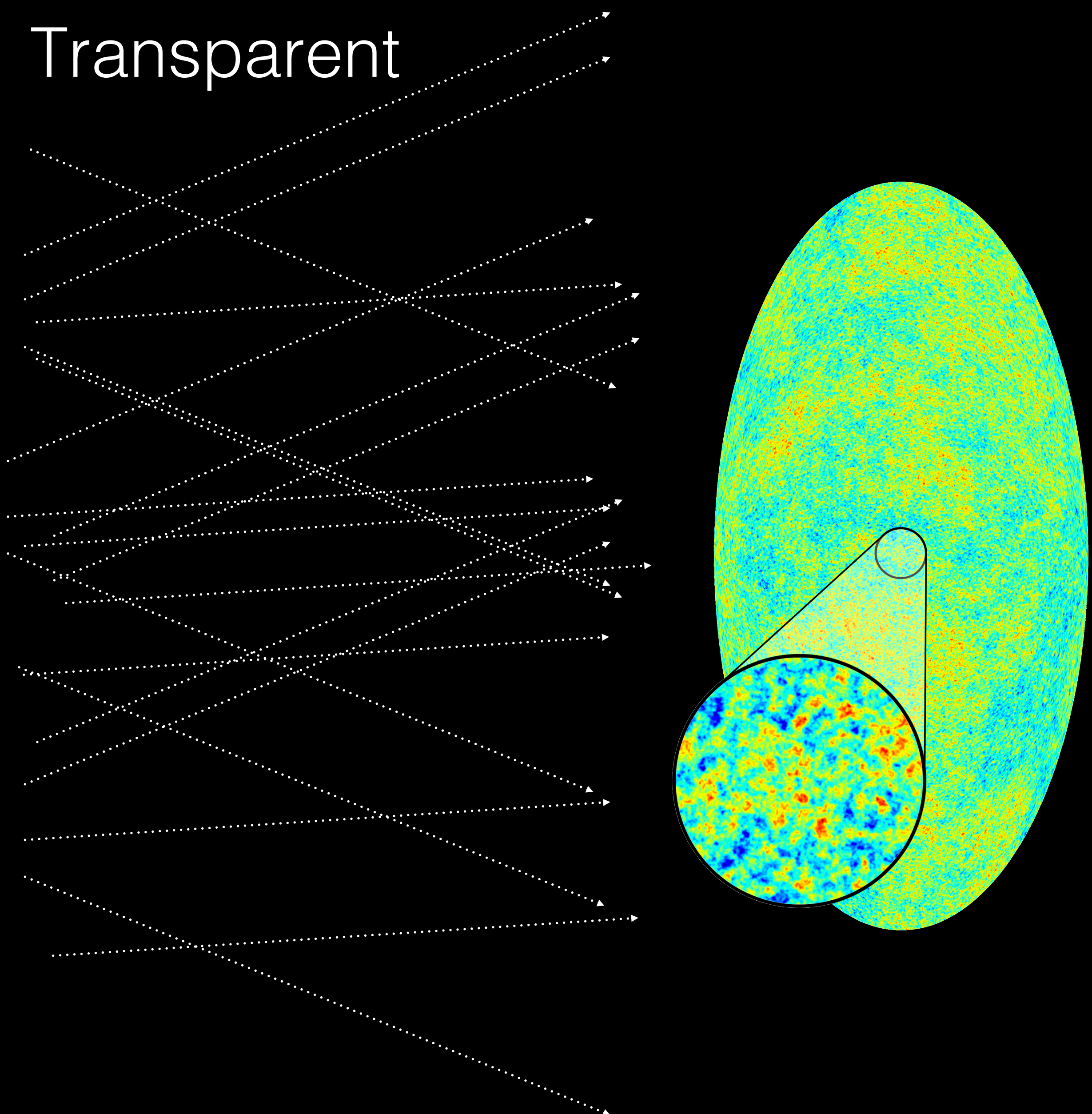
13.7 bn yrs

Plasma

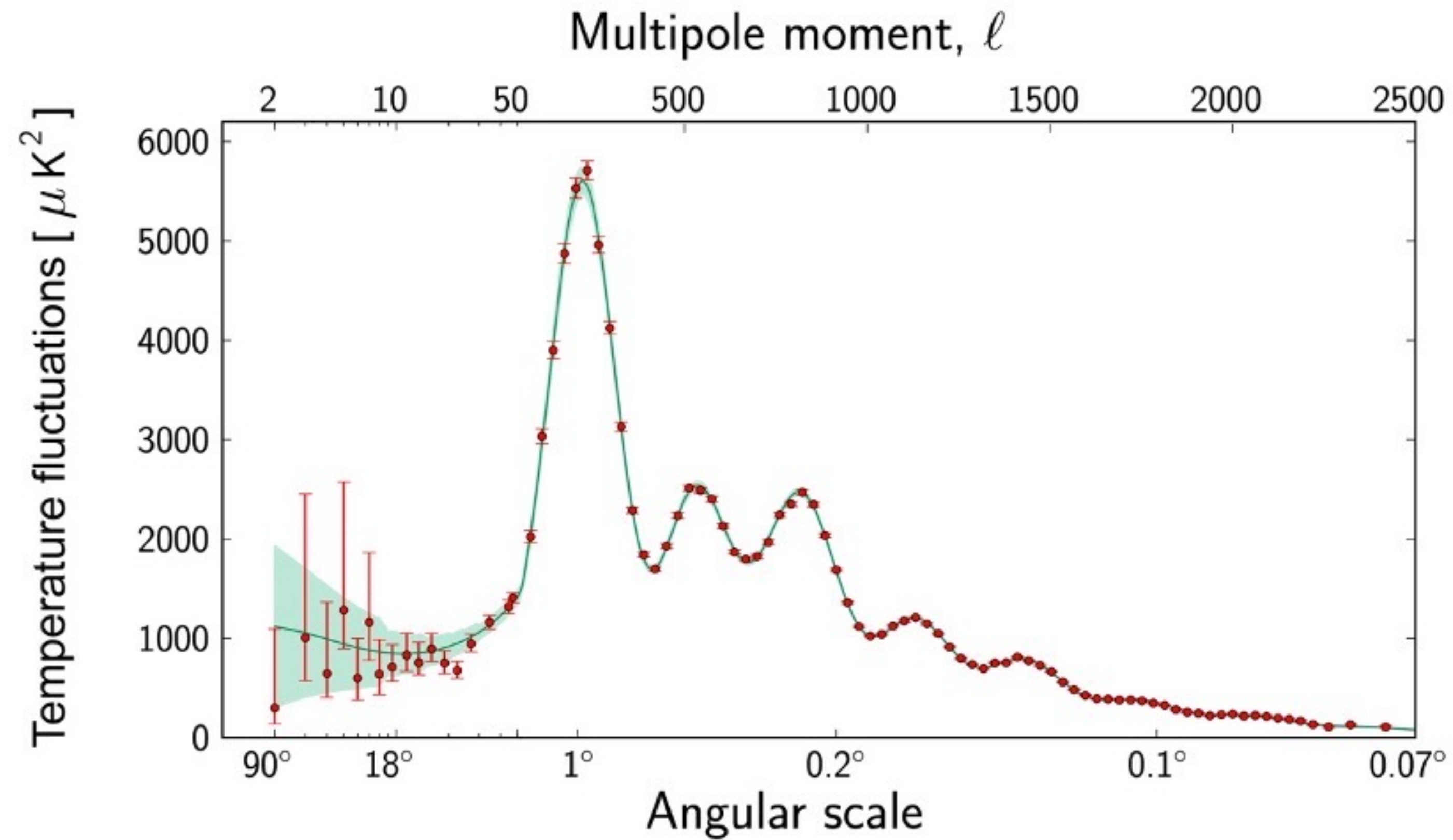


380,000 yrs

Transparent



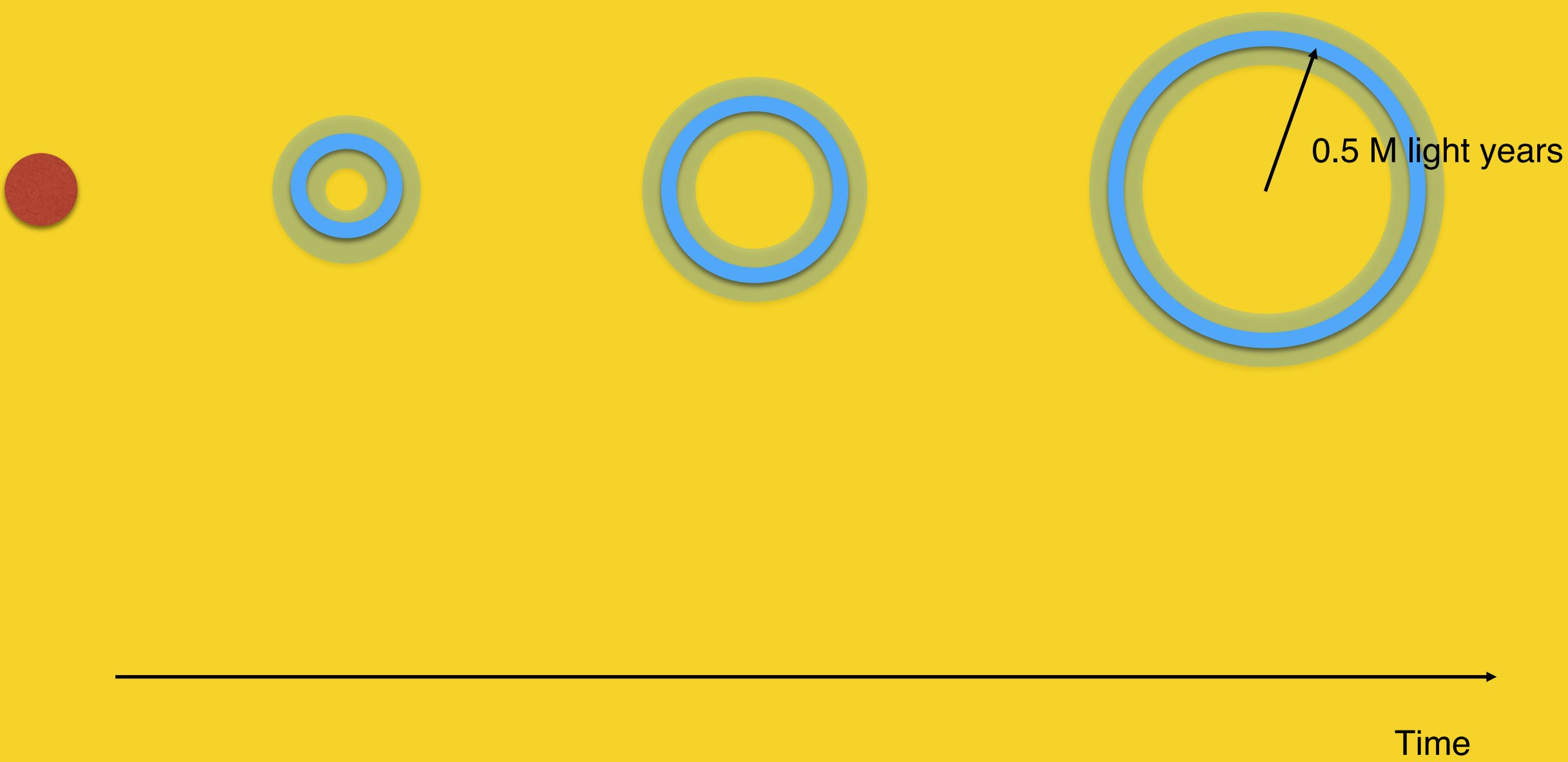
The Big Bang Rumble



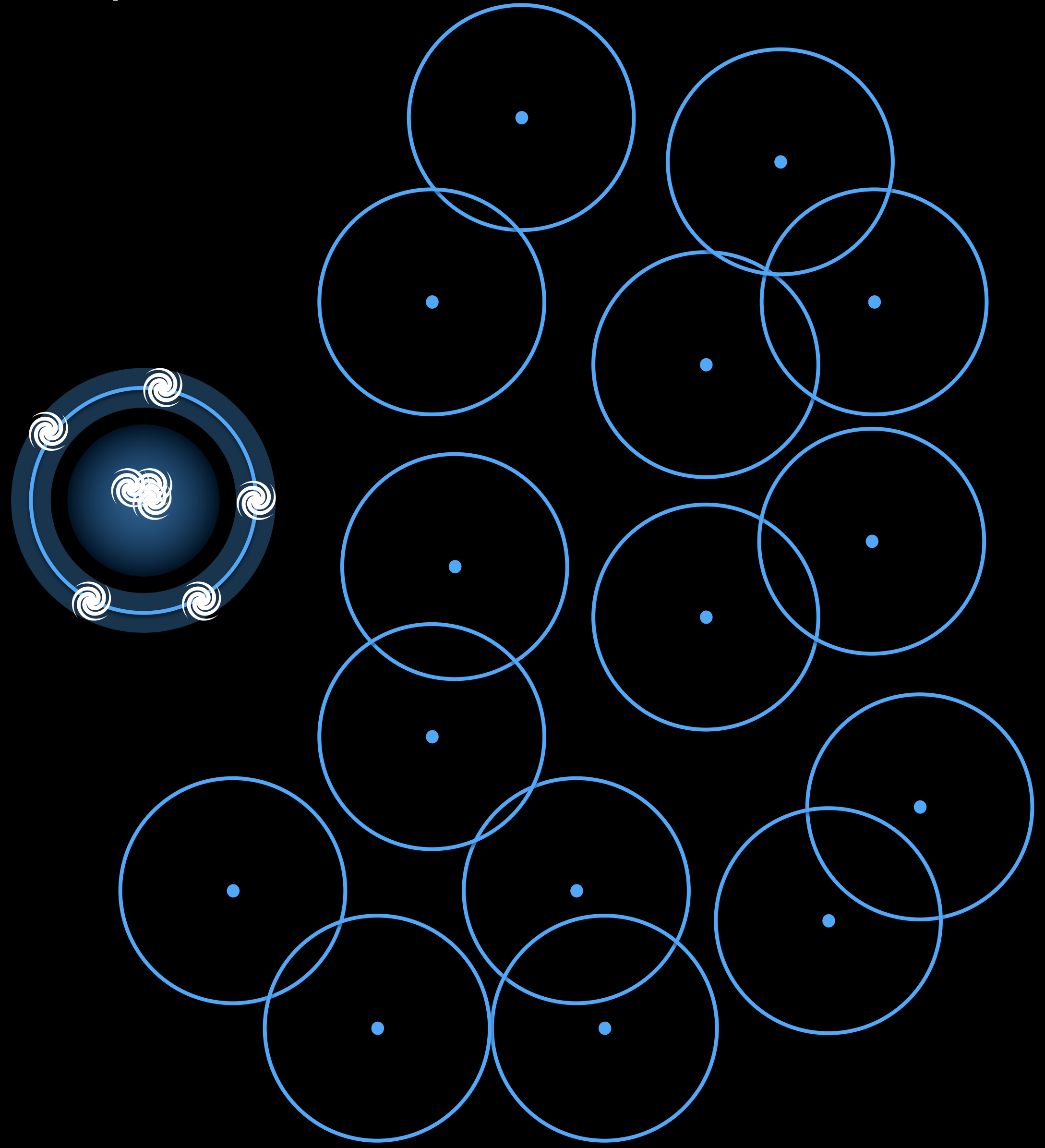
Audio "translation" by John G. Cranmer (U. Washington), from:
http://faculty.washington.edu/jcramer/BBSound_2013.html



Plasma

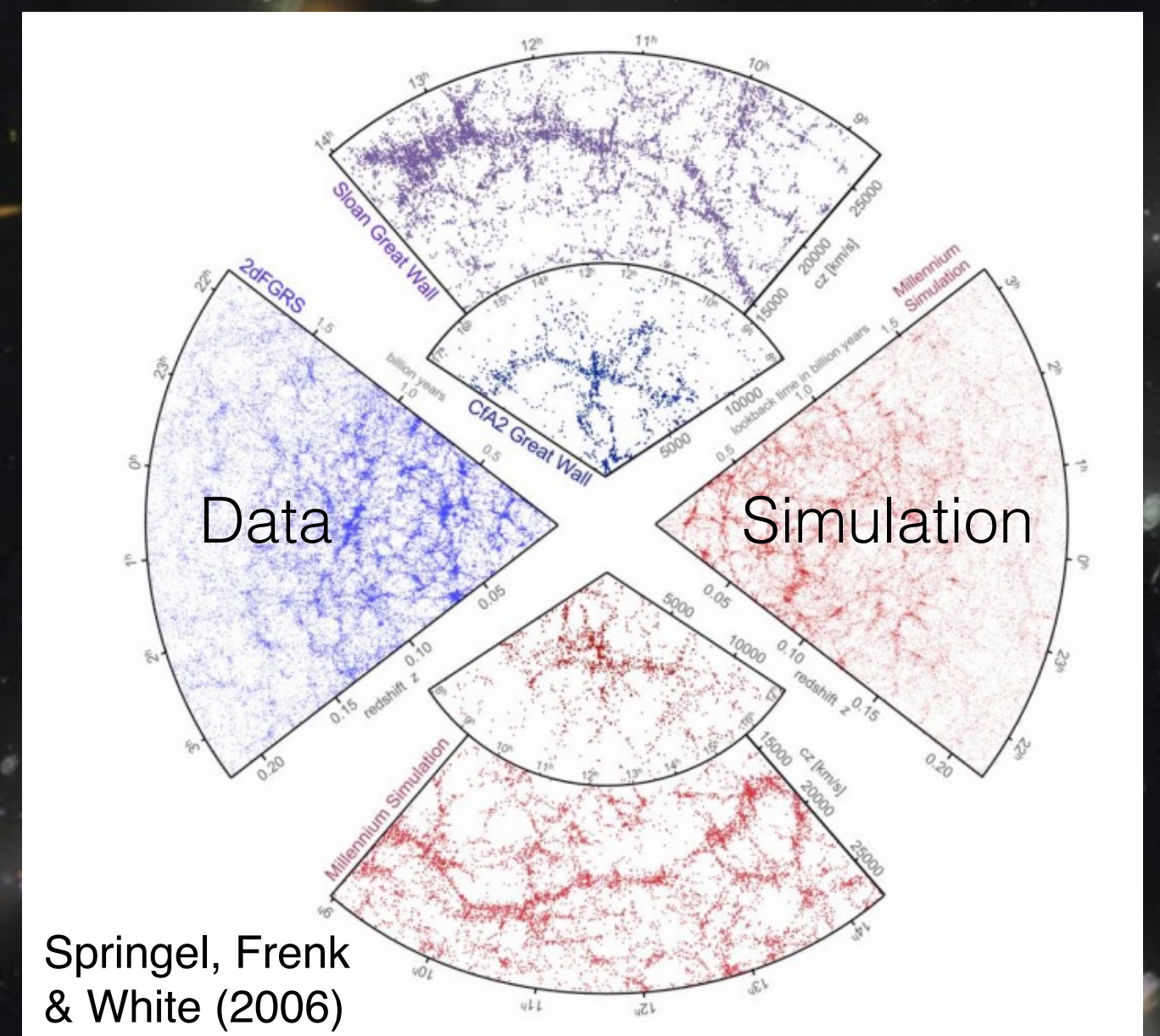


Transparent

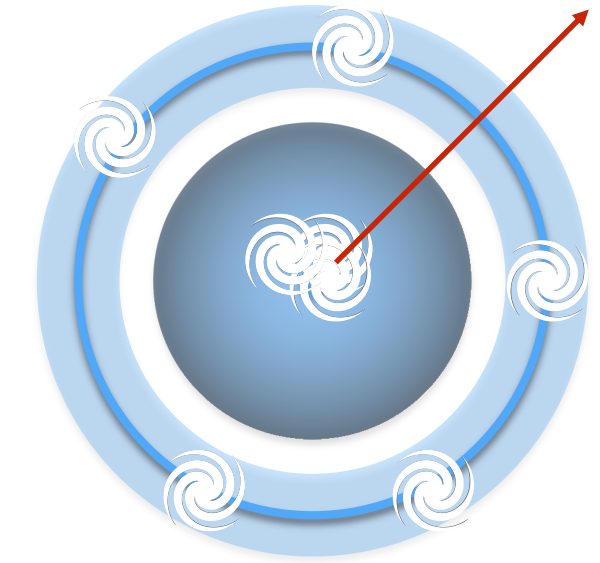
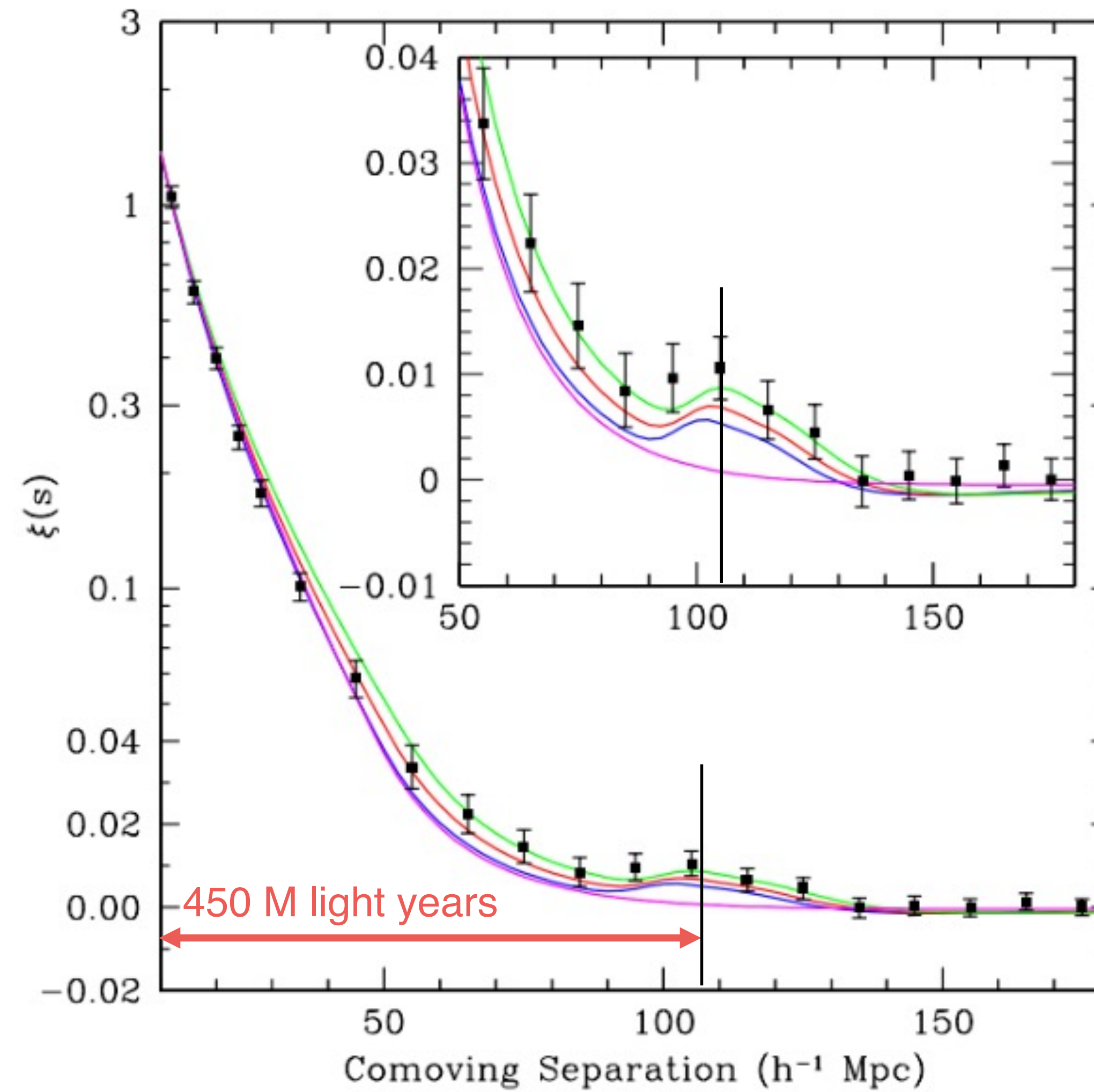


Surfing the Cosmic Sound Crests

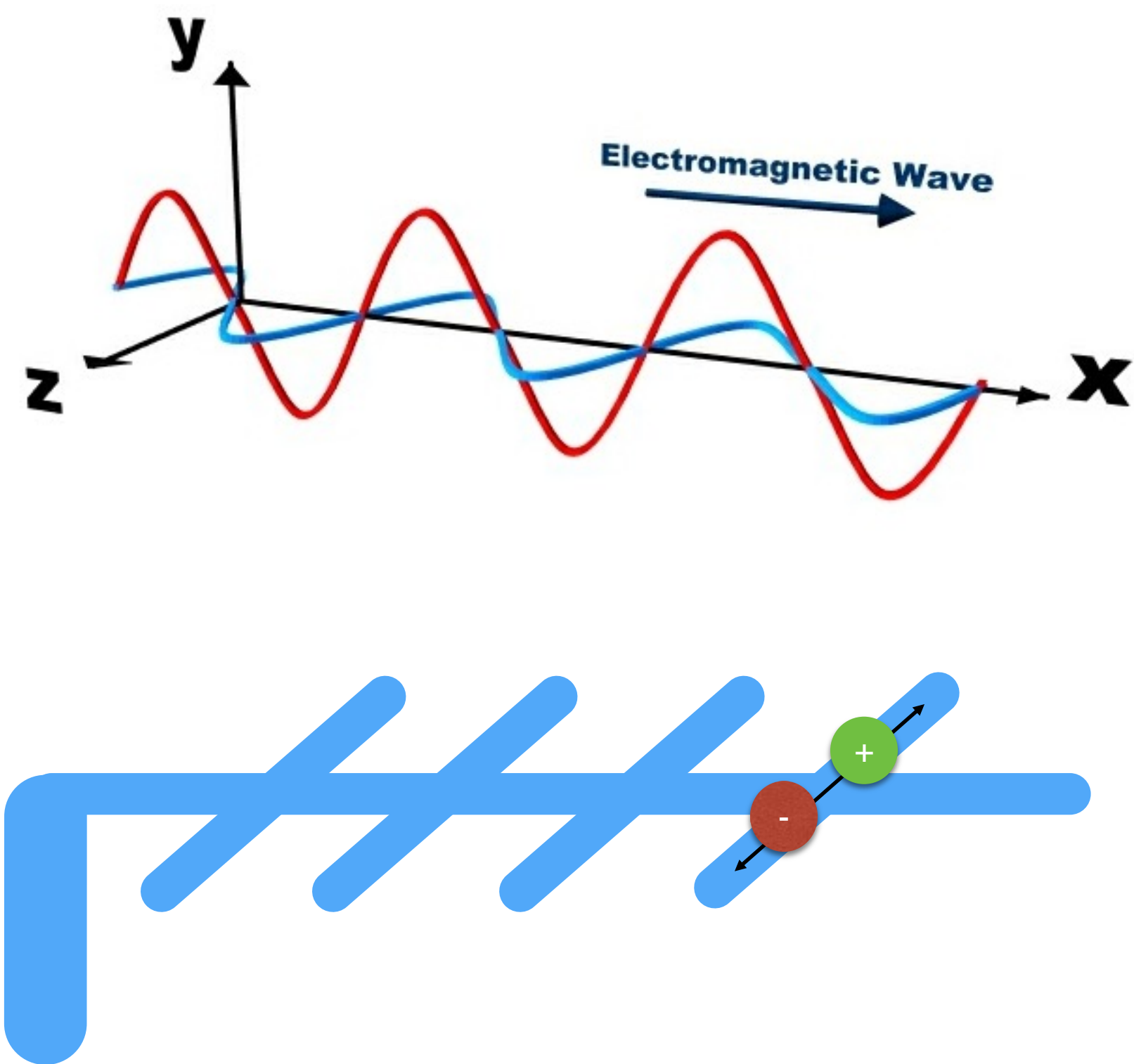
450 M light
years
(today)



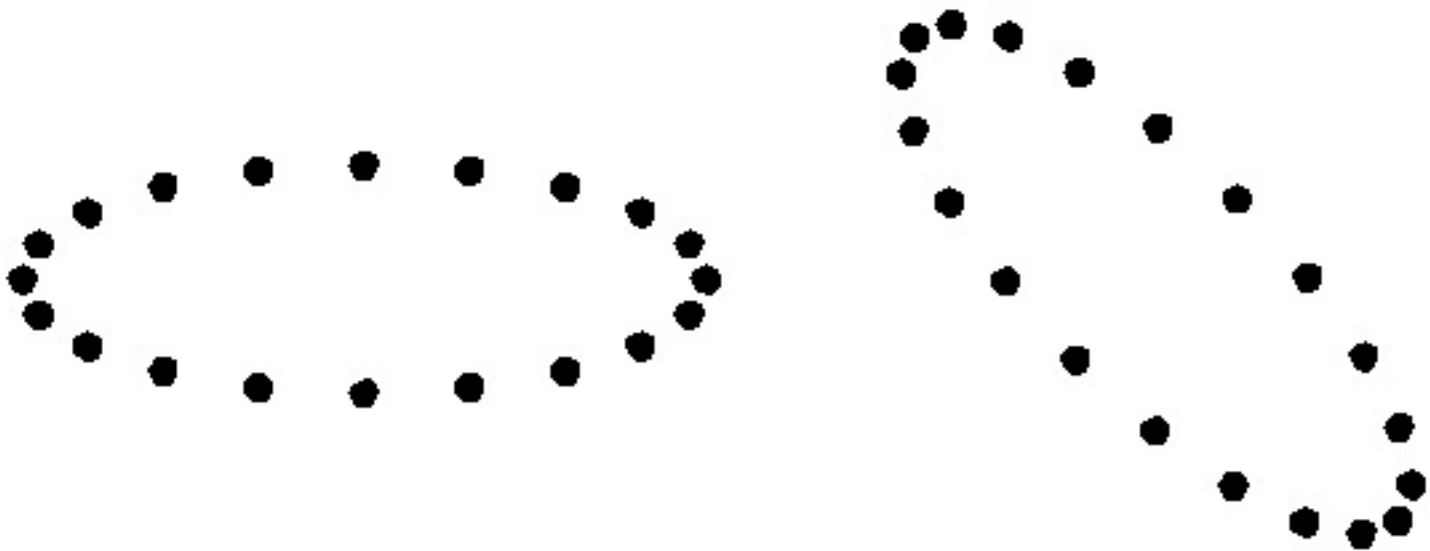
Catching the Wave



Electromagnetic



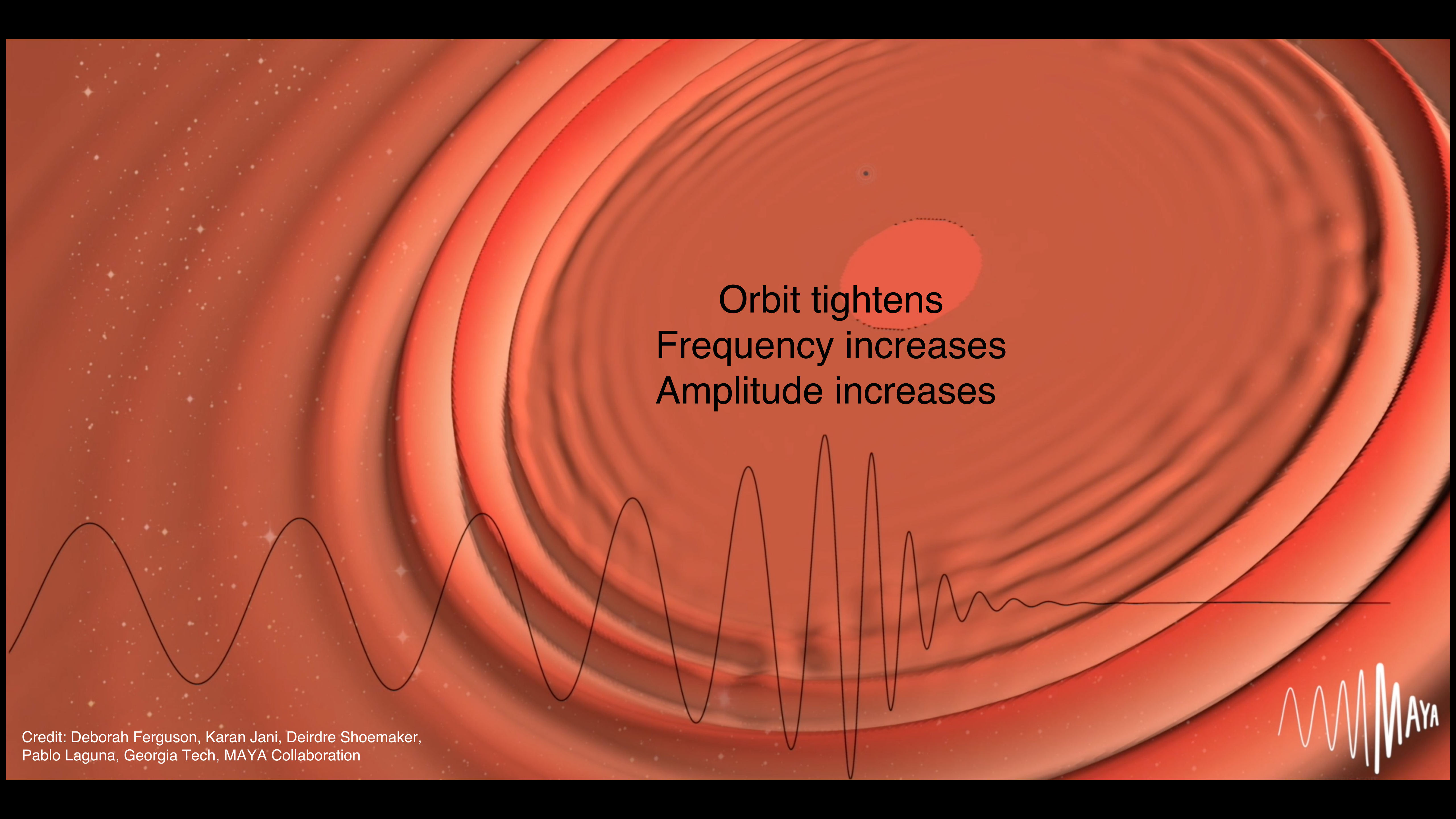
Gravitational





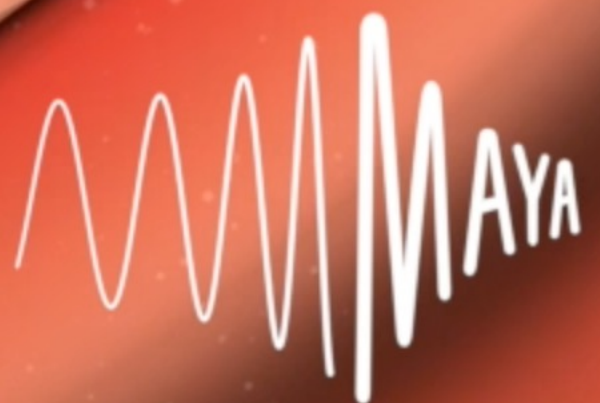
Credit: Deborah Ferguson, Karan Jani, Deirdre Shoemaker,
Pablo Laguna, Georgia Tech, MAYA Collaboration

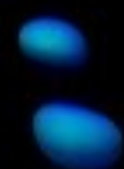




Orbit tightens
Frequency increases
Amplitude increases

Credit: Deborah Ferguson, Karan Jani, Deirdre Shoemaker,
Pablo Laguna, Georgia Tech, MAYA Collaboration





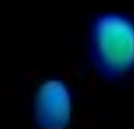
GW150914



GW151012



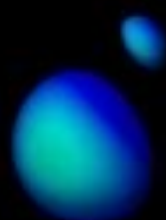
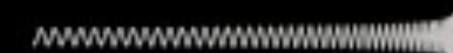
GW151226



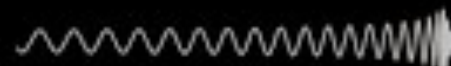
GW170104



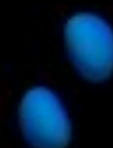
GW170608



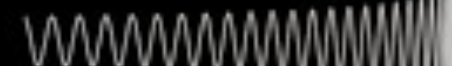
GW170729



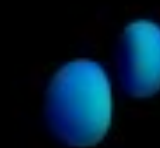
GW170809



GW170814



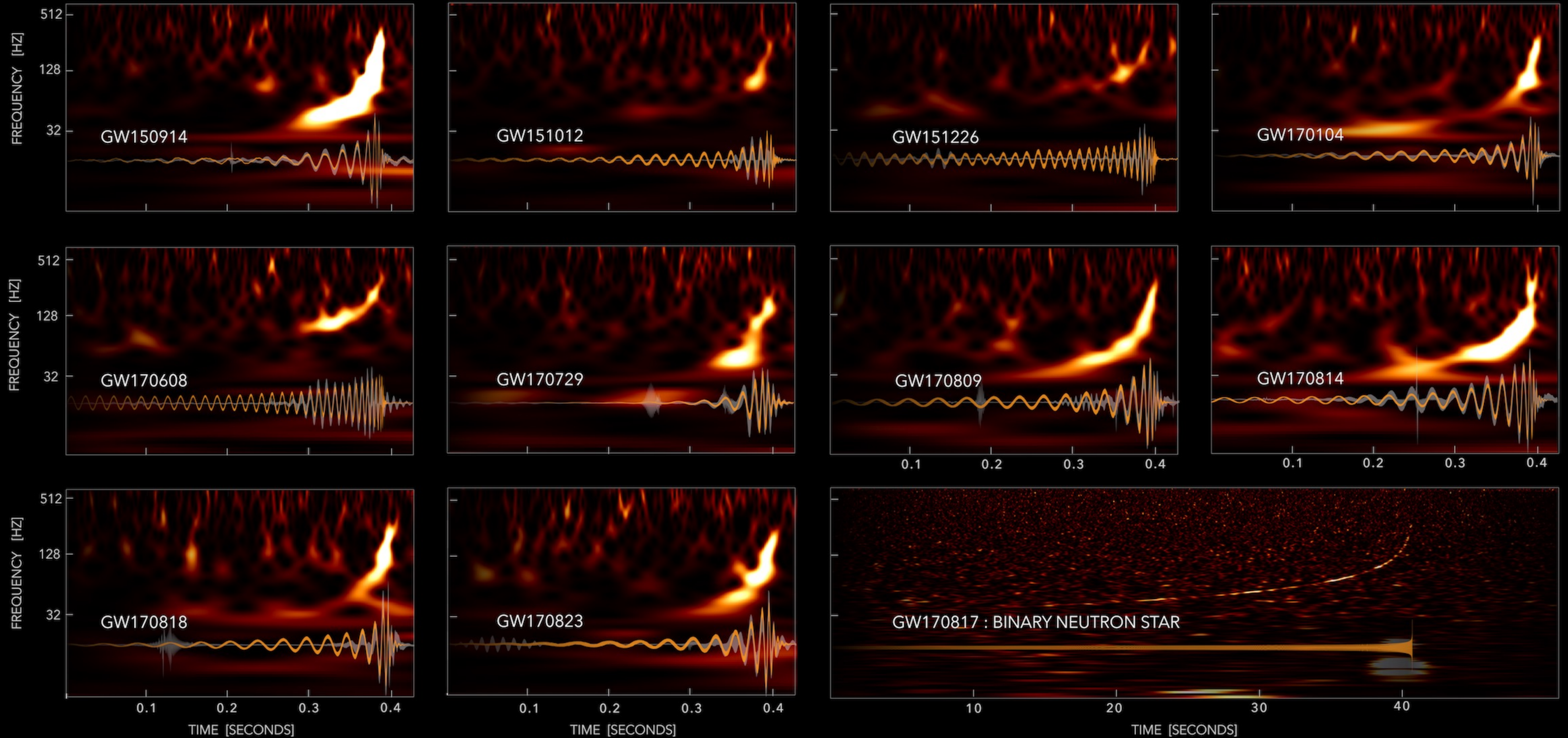
GW170818



GW170823



GRAVITATIONAL-WAVE TRANSIENT CATALOG-1



Simulations of gravitational waves signals by Scott A. Hughes and collaborators (MIT):

“The duration of the waves (months to years) far exceeds what we imagine you are willing to sit through. We fudged things a bit: In these cases, frequencies are shifted by a factor of a few thousand from the way that nature would actually present them. Think of it as the audio equivalent of a “false color” image”

The Neutron Star and the Supermassive Black Hole



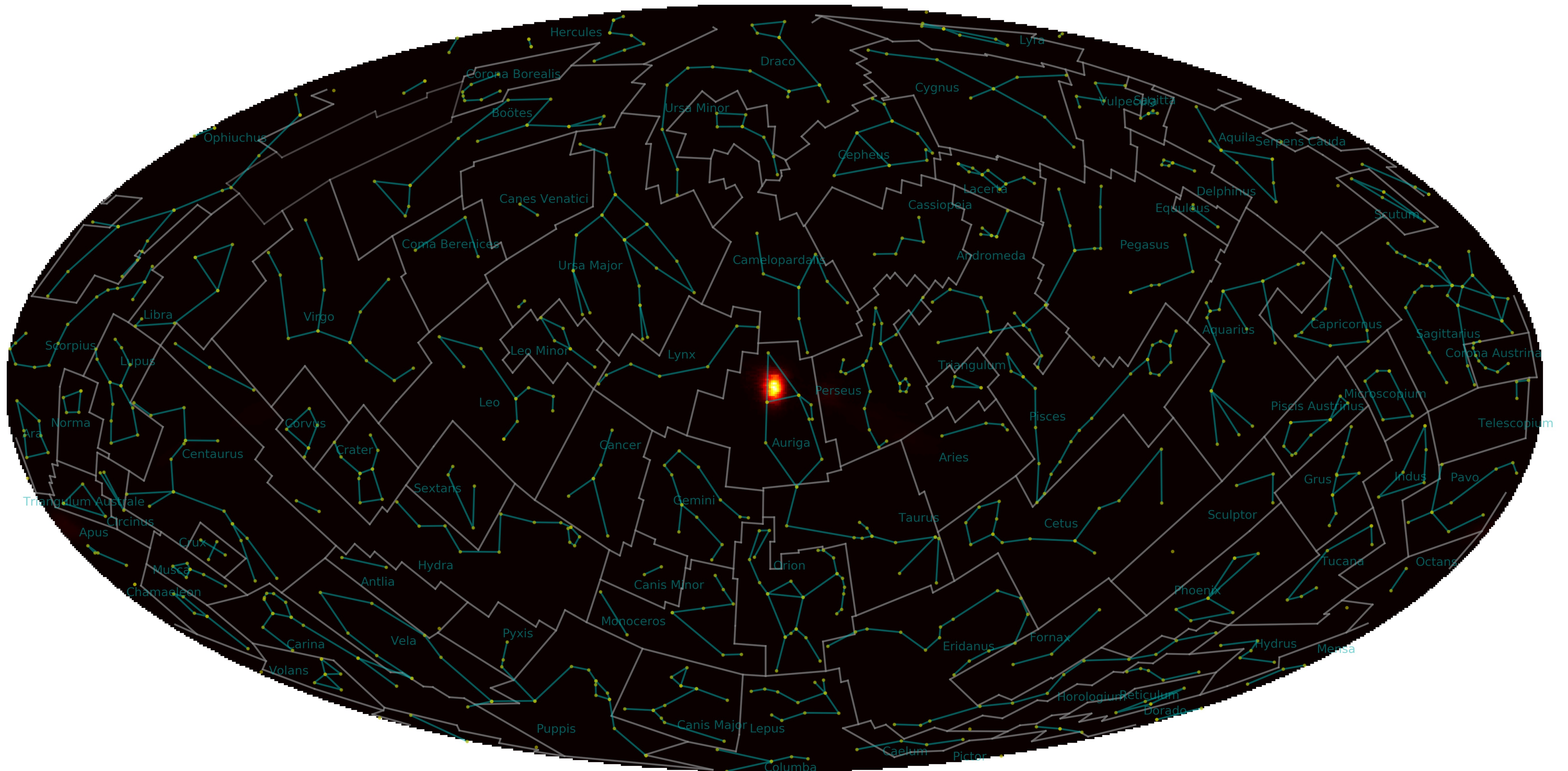
The Spinning Binary Black Holes



Sounds available from:
<http://gmunu.mit.edu/sounds/>

Gravitational Waves as Cosmic Sirens





Thank you!

 @R_Trotta

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