Observational Astronomy
Astr 469

Prof Sarah Burke-Spolaor ("Sarah")

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Today

- Few logisitics and course overview
- Brief overview of observational astronomy
- Foundations of the basics
  - Messengers from the sky!
  - The electromagnetic spectrum
  - Units and angles
  - Using solid angles
  - Order-of-magnitude estimation

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The world's astrophysical suite.

Keck, Sloan, Gemini, ELTs, ...

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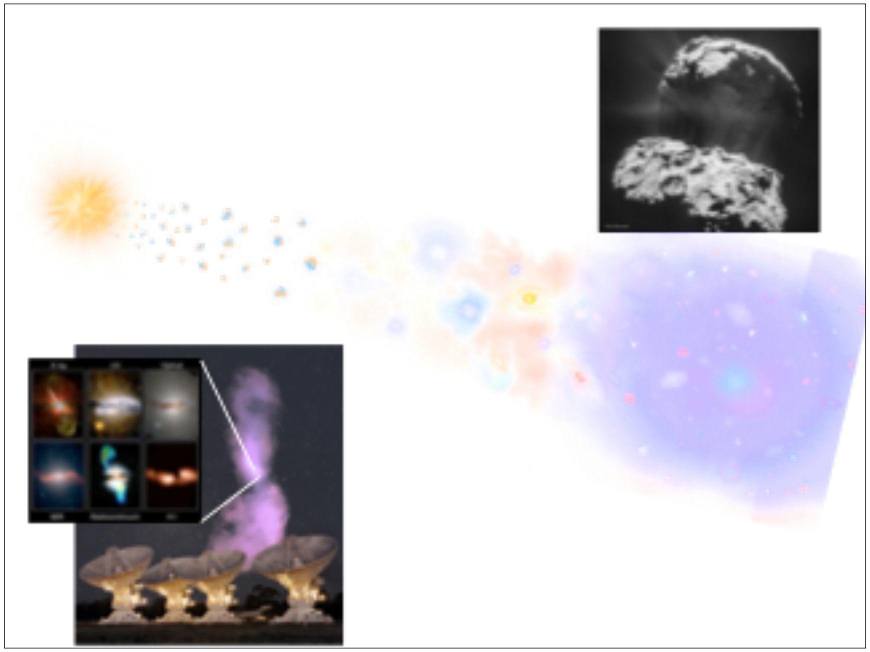

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Cave paintings, France

France: Cave paintings from 18,000 B.C. may suggest knowledge of lunar phases (29 dots)

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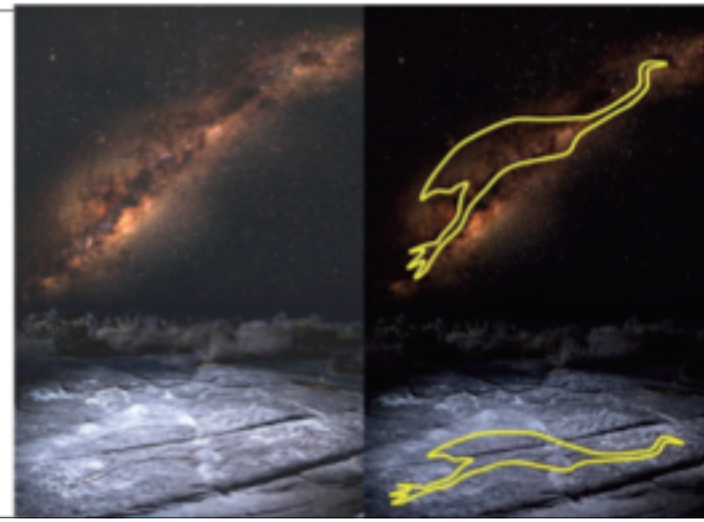
Aboriginal Astronomy (Australia)



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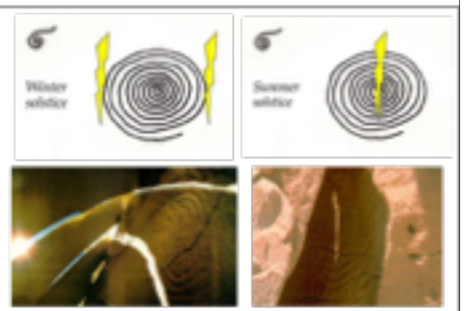
Telling Time…

Egyptian Obelisks: Time of day



American Southwest (and worldwide) Stone/sun/shadow alignments: Time of year

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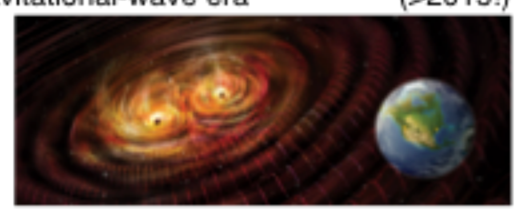
Phases of astronomy…

- Ancient/primitive
- Optical/Infrared era (>1600s)
- Electromagnetic and neutrino era (>1900s)
- Gravitational-wave era (>2015!)



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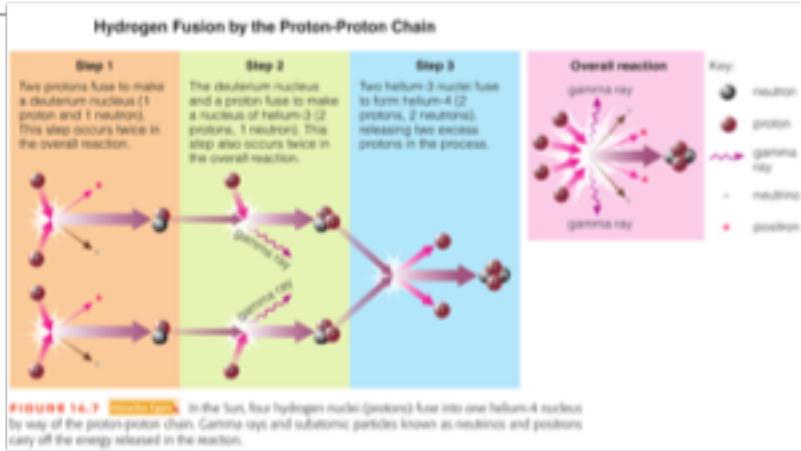
Note: Neutrinos



Not the same thing as cosmic rays, which are relativistic electrons, protons.

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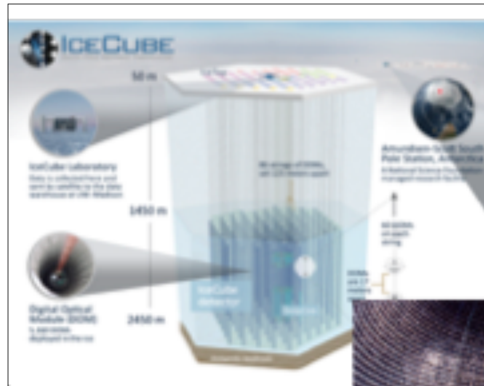

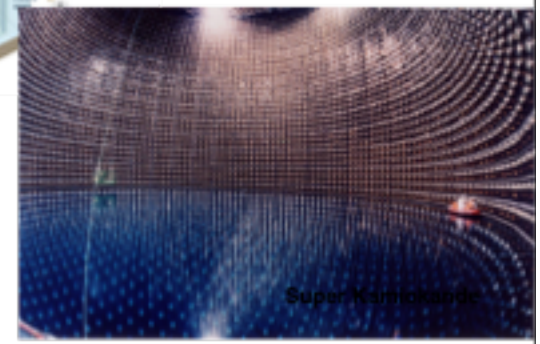

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X-rays, Gamma rays

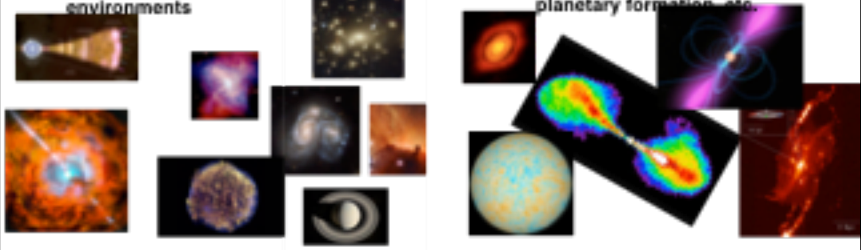
Explosions, highly energetic events, supernovae, black hole environments

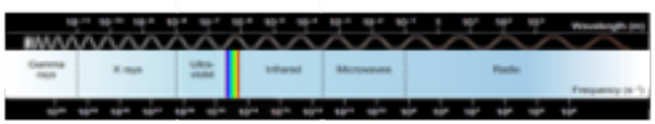
UV/Optical/IR

Planets, stars, galaxies, dust, star formation.

Radio

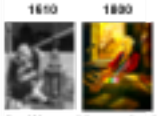
Cosmic microwave background, Black hole jets, space lasers (masers), transient phenomena, pulsars, molecular clouds, planetary formation, etc.





1992

1610 1800



Galileo, Herschel

1931

Jansky's radio antenna

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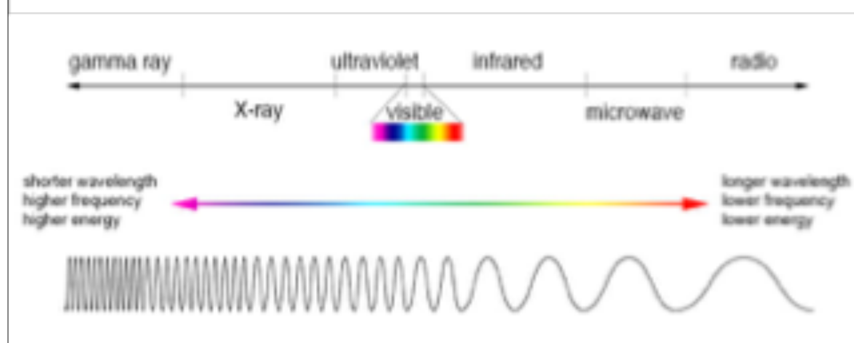
Electromagnetic Radiation



emember all wavelengths are light, and travel at speed c

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Astronomical Wavelength Regimes

Name	Wavelength	Frequency (Hz)	Photon Energy (eV)
Gamma ray	Less than 0.01 nm	more than 10 EHz	100 kev - 300+ GeV
X - ray	0.01 - 10 nm	30 EHz - 30 PHz	120 eV - 120 keV
Ultraviolet	10 nm - 400 nm	30 PHz - 790 THz	3 eV - 124 eV
Visible	390 nm - 750 nm	790 THz - 405 THz	1.7 eV - 3.3 eV
Infrared	750 nm - 1 mm	405 THz - 300 GHz	1.24 meV -1.7 eV
Microwave	1 mm - 1 meter	300 GHz - 300 MHz	1.24 μ eV - 1.24 meV
Radio	1 mm - km	300 GHz - 3 Hz	12.4 feV - 1.24 meV

Note: OOM approximation is a useful thing to practice!

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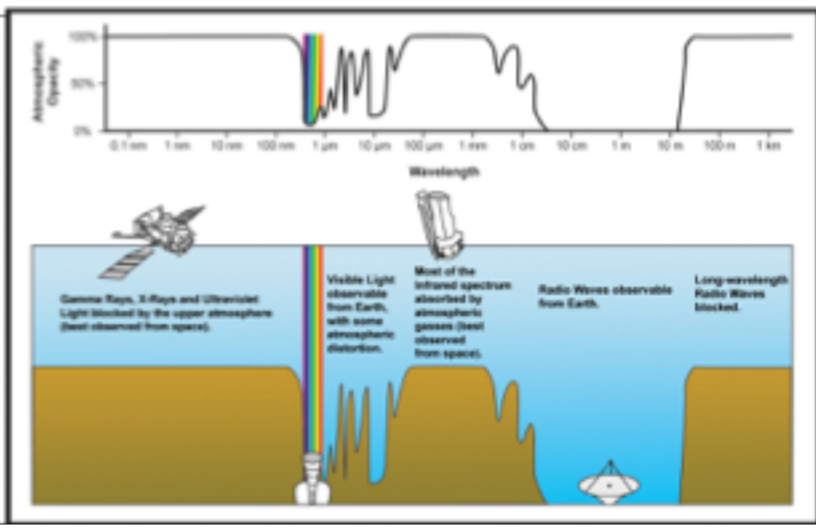
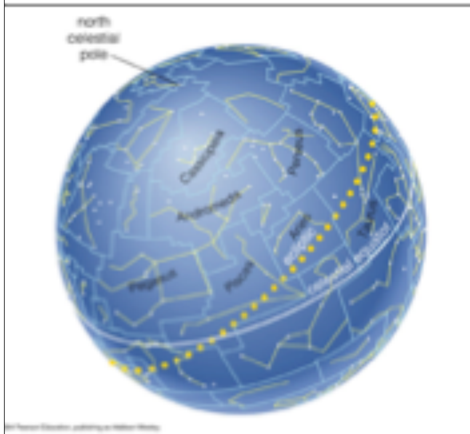
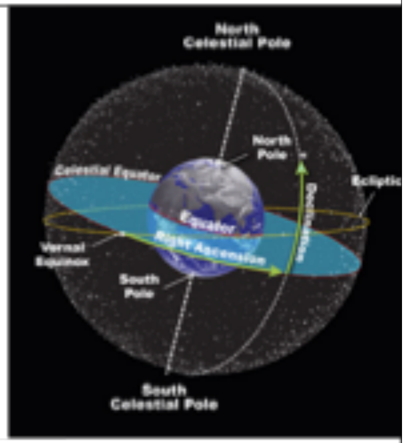
The terrible effects of air!



And now for something completely different…

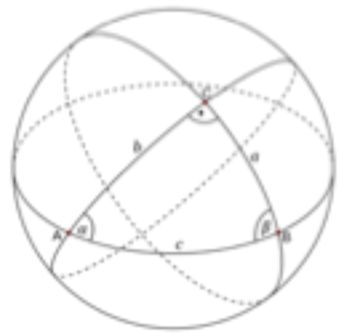
Basics of Observations





We observe everything projected onto the celestial sphere

Spherical Trig



- Tycho Brahe said that the nature of understanding spherical triangles is so divine and elevated that it is not appropriate to extend its mysteries to everyone

Spherical Trig

Everything is observed on the celestial sphere!

The separation between objects is measured in angles

The area of an object can be measured in squared angles (e.g., deg^2) or steradians

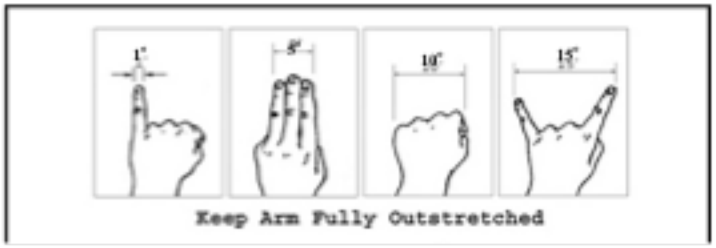
Angles

Deg, Arcmin, Arcsec

vs.

Radians

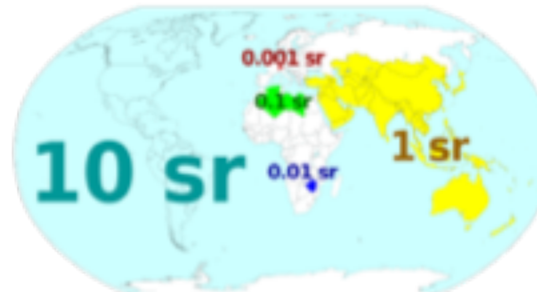
Angles in Astronomy



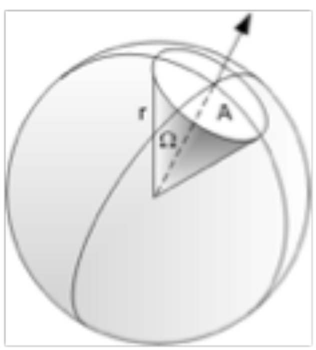
Steradians

Steradians are:

- Dimensionless (squared radian)
- "Angular surface area"



Solid angles/Steradians



Steradians

Note: Small angle approximation!

- For small angles [from Taylor series]:

$$\tan(\theta) \approx \theta$$

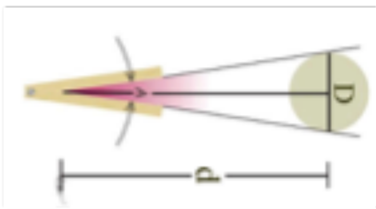
$$\cos(\theta) \approx 1 - \frac{\theta^2}{2}$$

$$\sin(\theta) \approx \theta$$

ONLY USE WITH θ IN RADIANS.

Exceedingly useful approximations
(But careful at θ > ~0.1 rad, or a few degrees)!

Angles in Astronomy



We often care about the actual size of objects, not just the angular size. We can use trig in this case:

tan(θ/2) = (D/2) / d

For small angles,

tan(θ/2) ~ sin(θ/2) ~ θ/2

So θ = D/d

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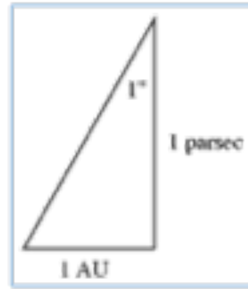
Parsecs



Parsec:
The distance at which 1 AU appears to be 1 arcsecond large.

1 pc = 3.08 x 10^{16} m

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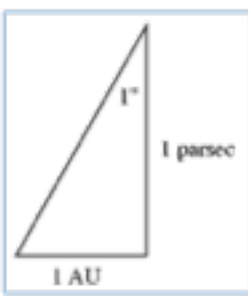
Parsecs



Parsec:
The distance at which 1 AU appears to be 1 arcsecond large.

1 pc = 3.08 x 10^{16} m

$$\tan(1'') = \frac{1\ \text{AU}}{1\ \text{pc}}$$

Easy way to remember the conversion!

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