ASTR 1040 Recitation: The Sun

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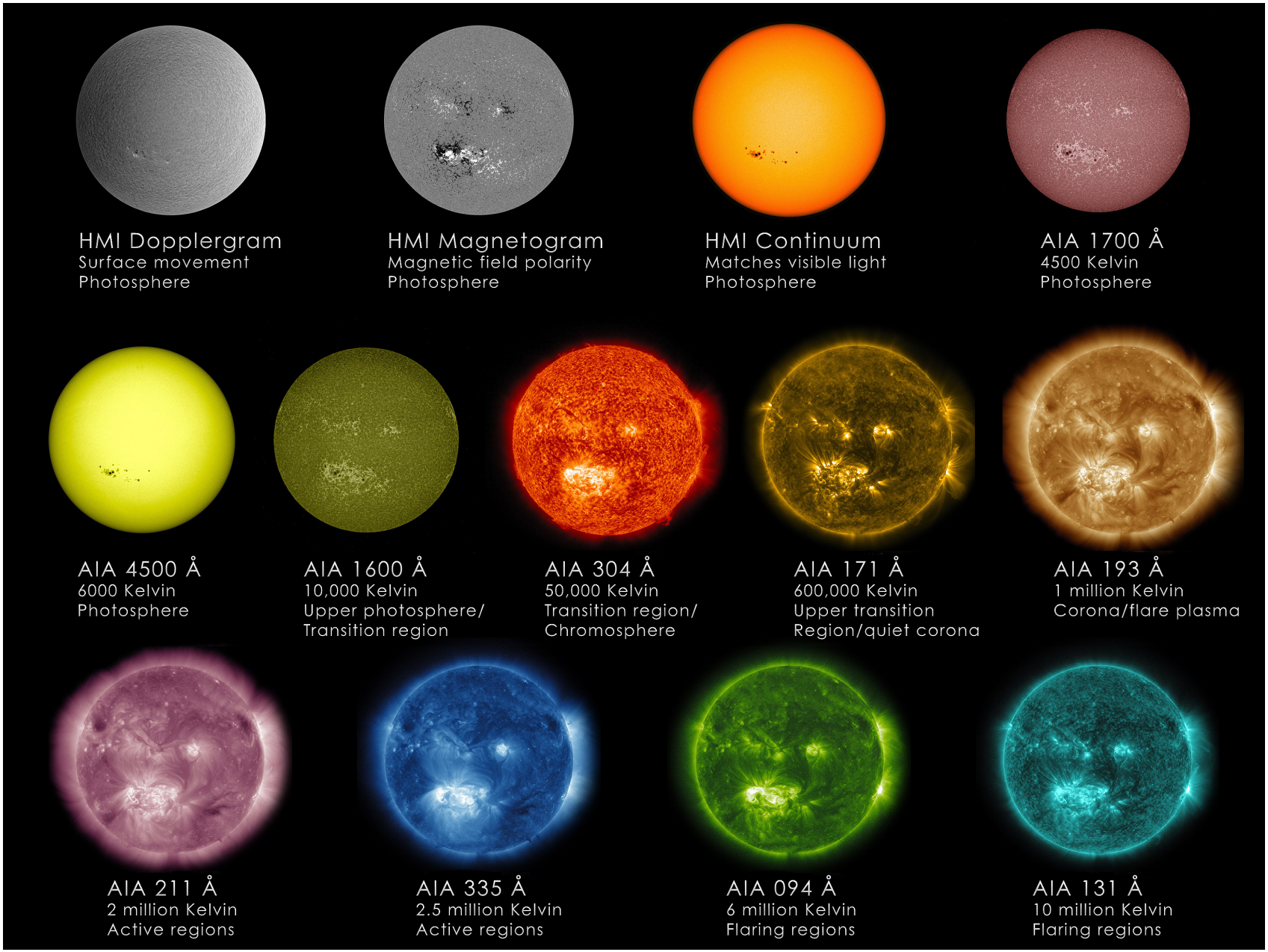
February 19 & 20, 2019

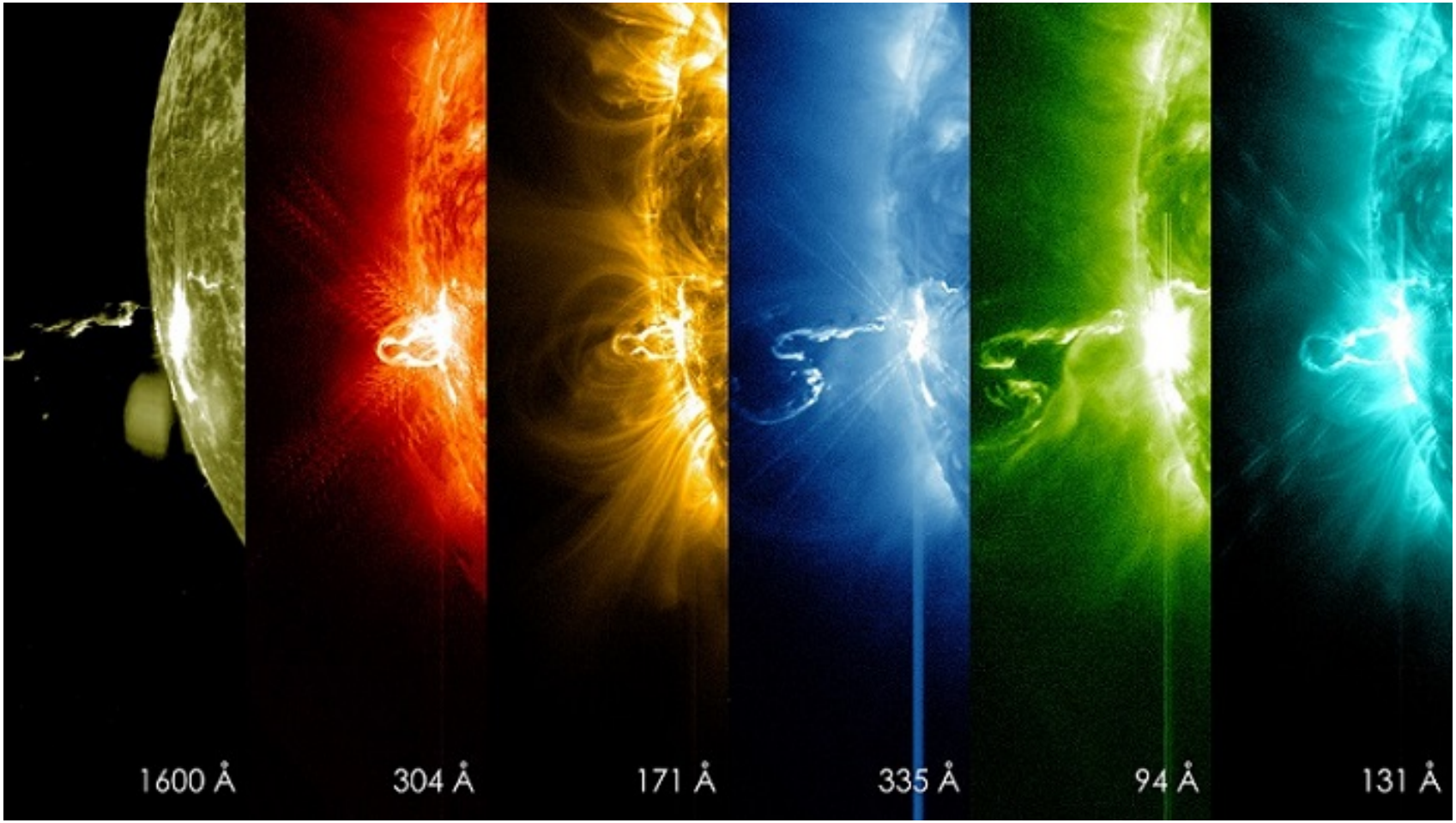
Announcements

- Next Observing: Wed, Feb 20 (8pm or 9pm at SBO)

The Sun using SDO



The Sun using SDO/AIA



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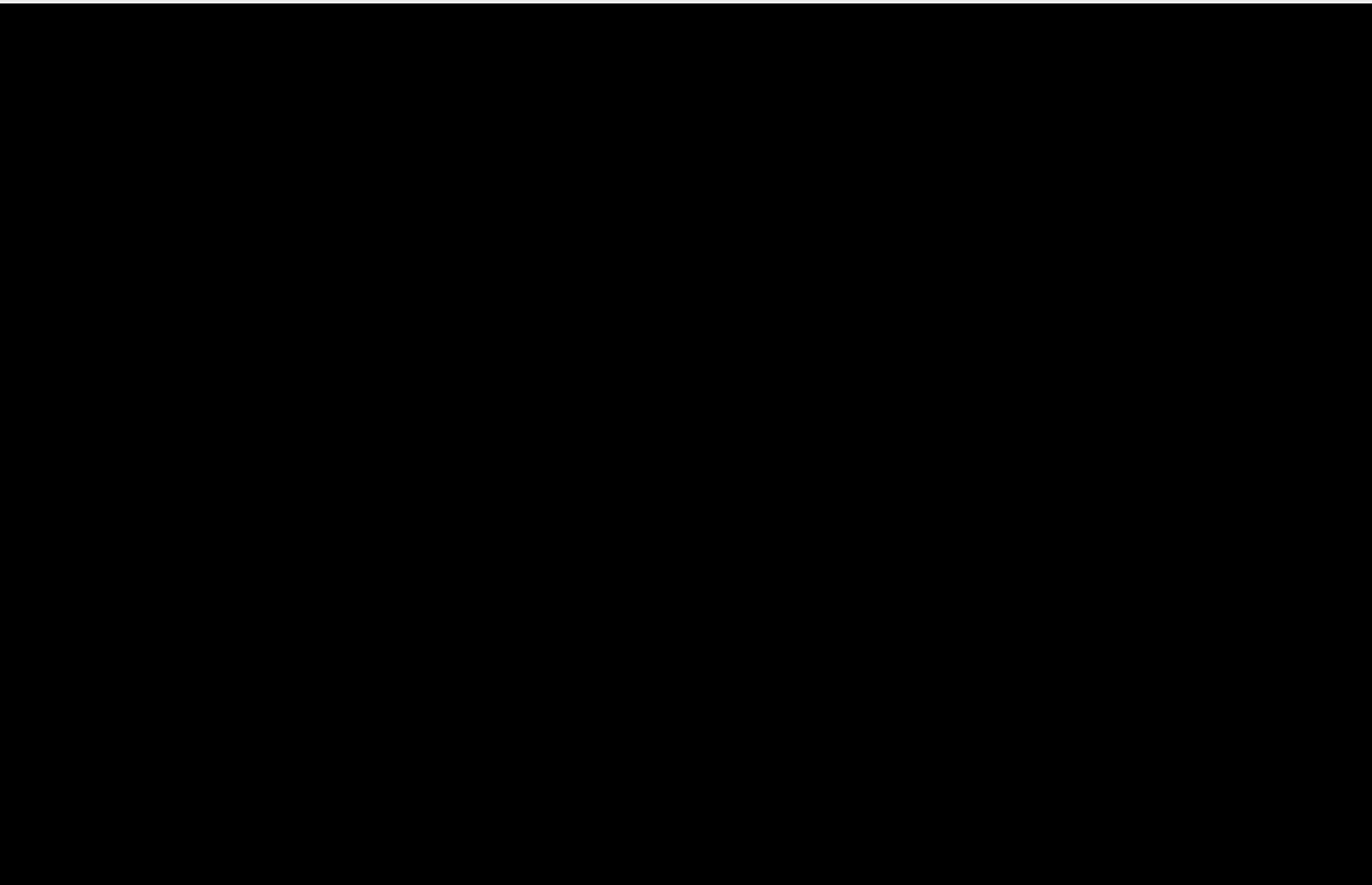
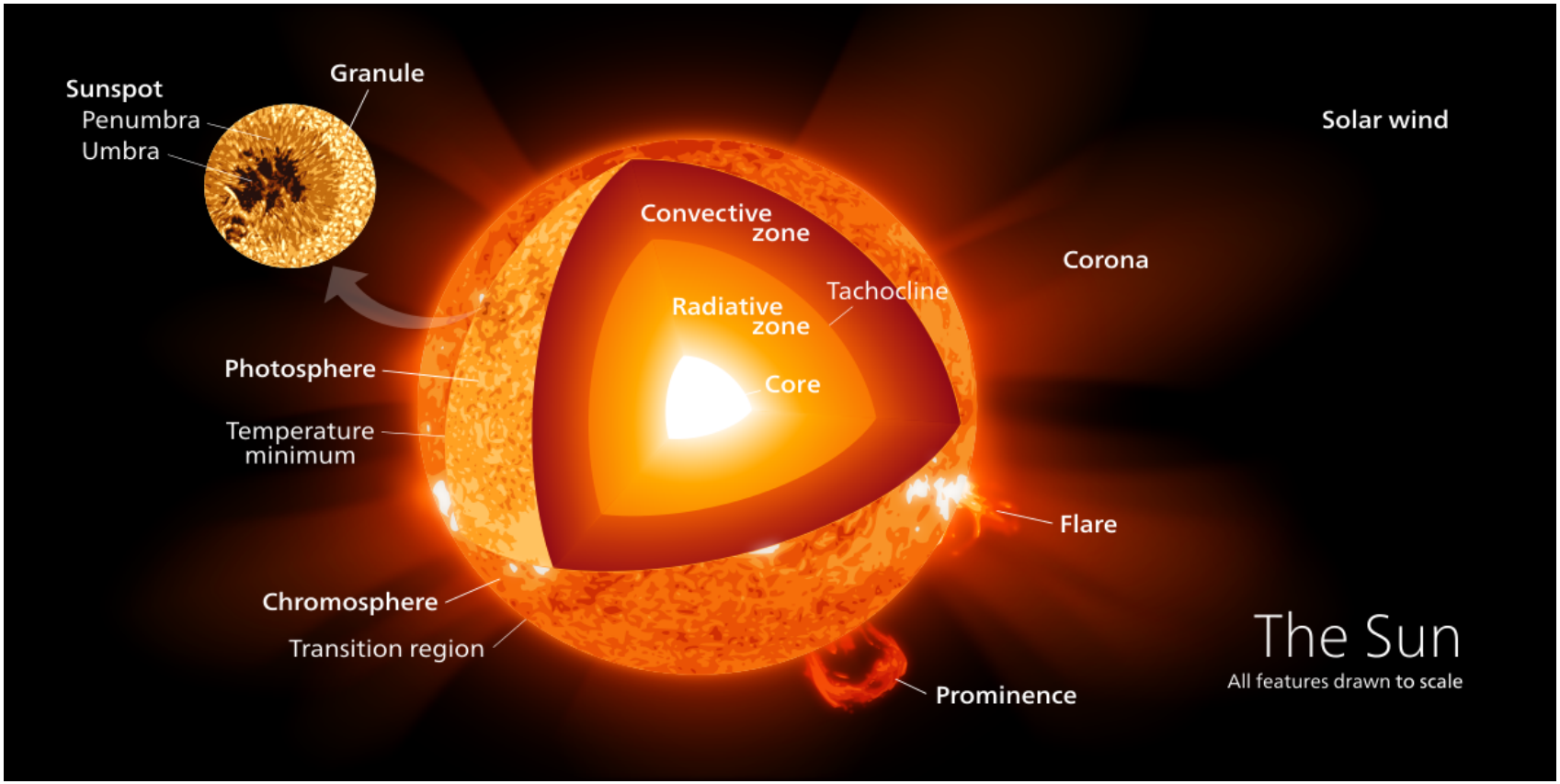
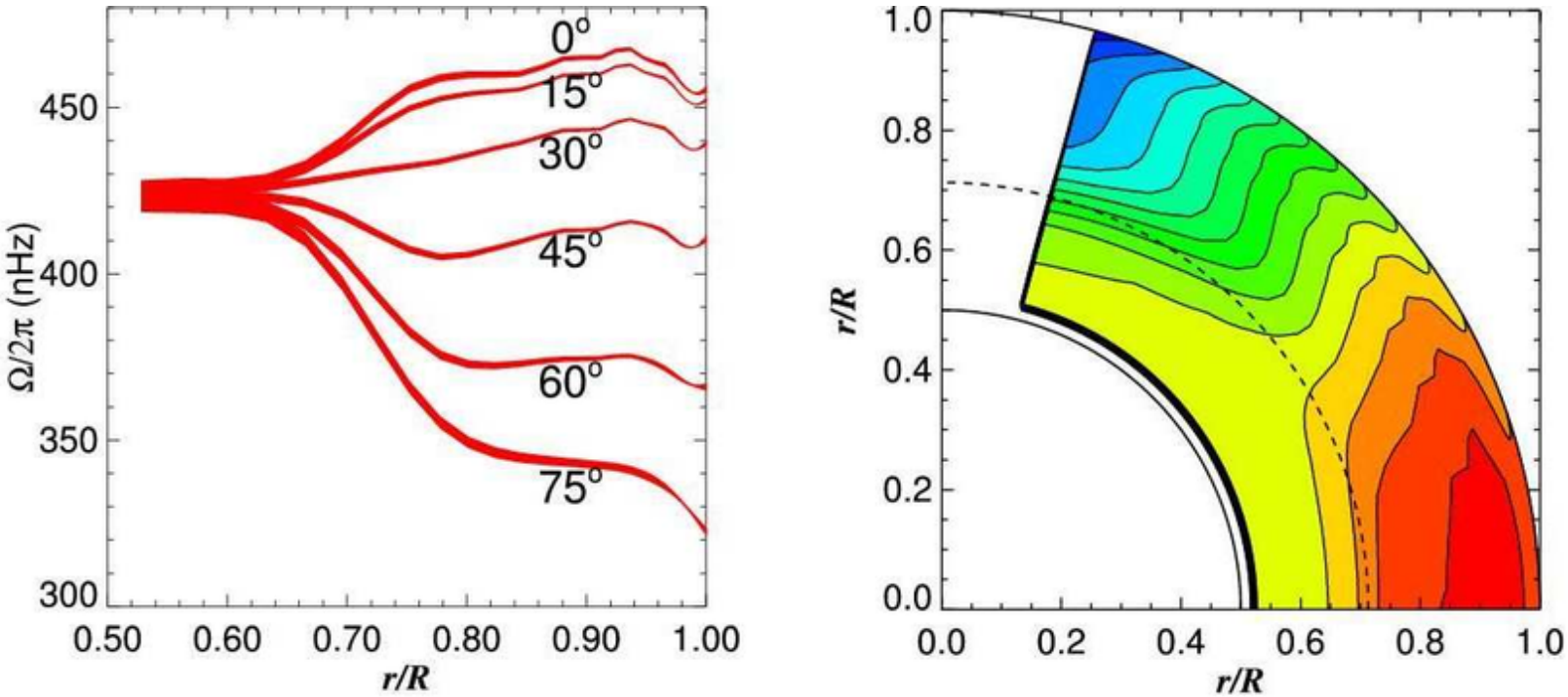


The Solar Interior

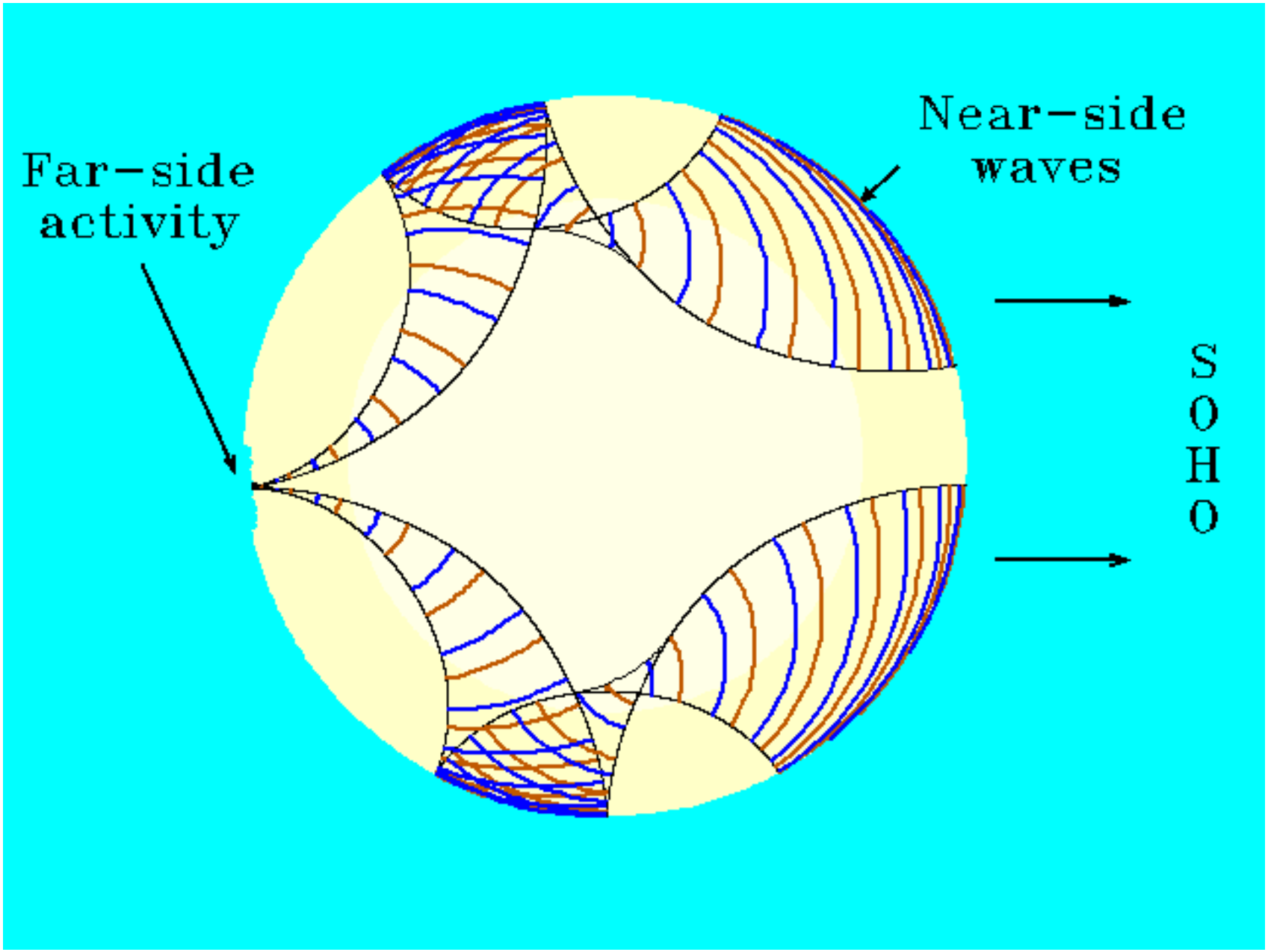


Differential Rotation



Fast equator, slow poles. Constant in radiative zone.

How Do We Know?



What Stops a Star From Collapsing?

Pressure

- Pressure = Force per area, $F = \int P \, \mathrm{d}A$
- Each particle has momentum, hits the wall (or particles)
- A change in momentum $\Rightarrow$ Force
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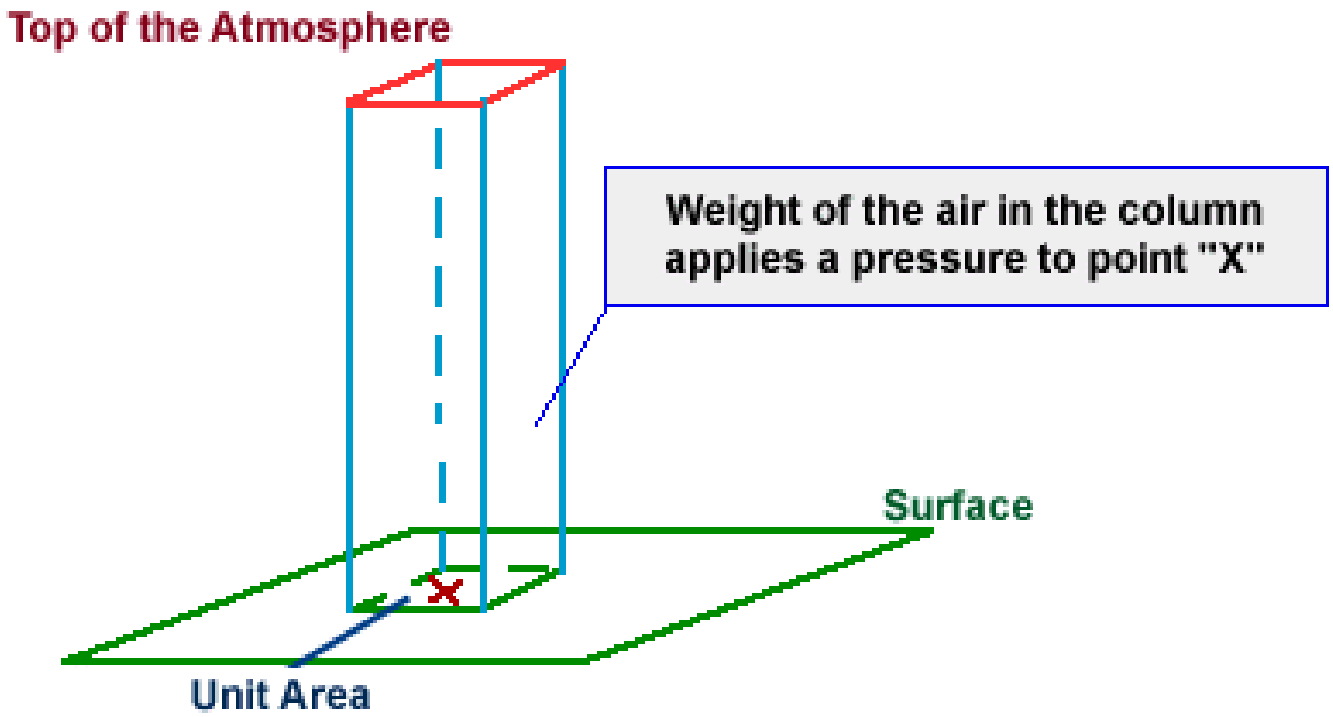
- Can you move a car with a laser pointer?
  - Not quite, maybe only a grain of sand. But photons carry momentum, thus exert a pressure

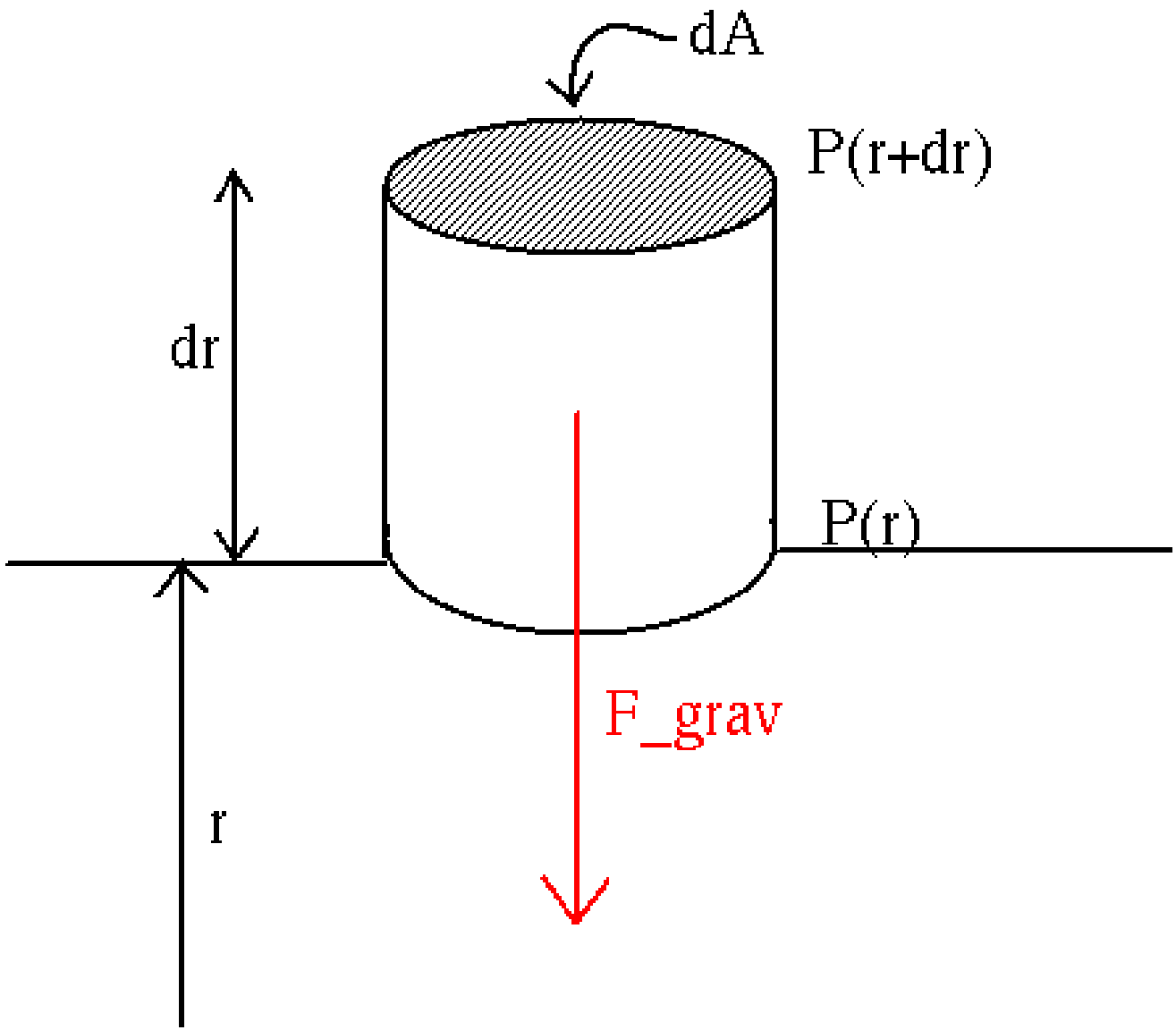
Stars are Static, Most of the Time



$$F = PA$$

Stars are Static

Hydrostatic Equilibrium



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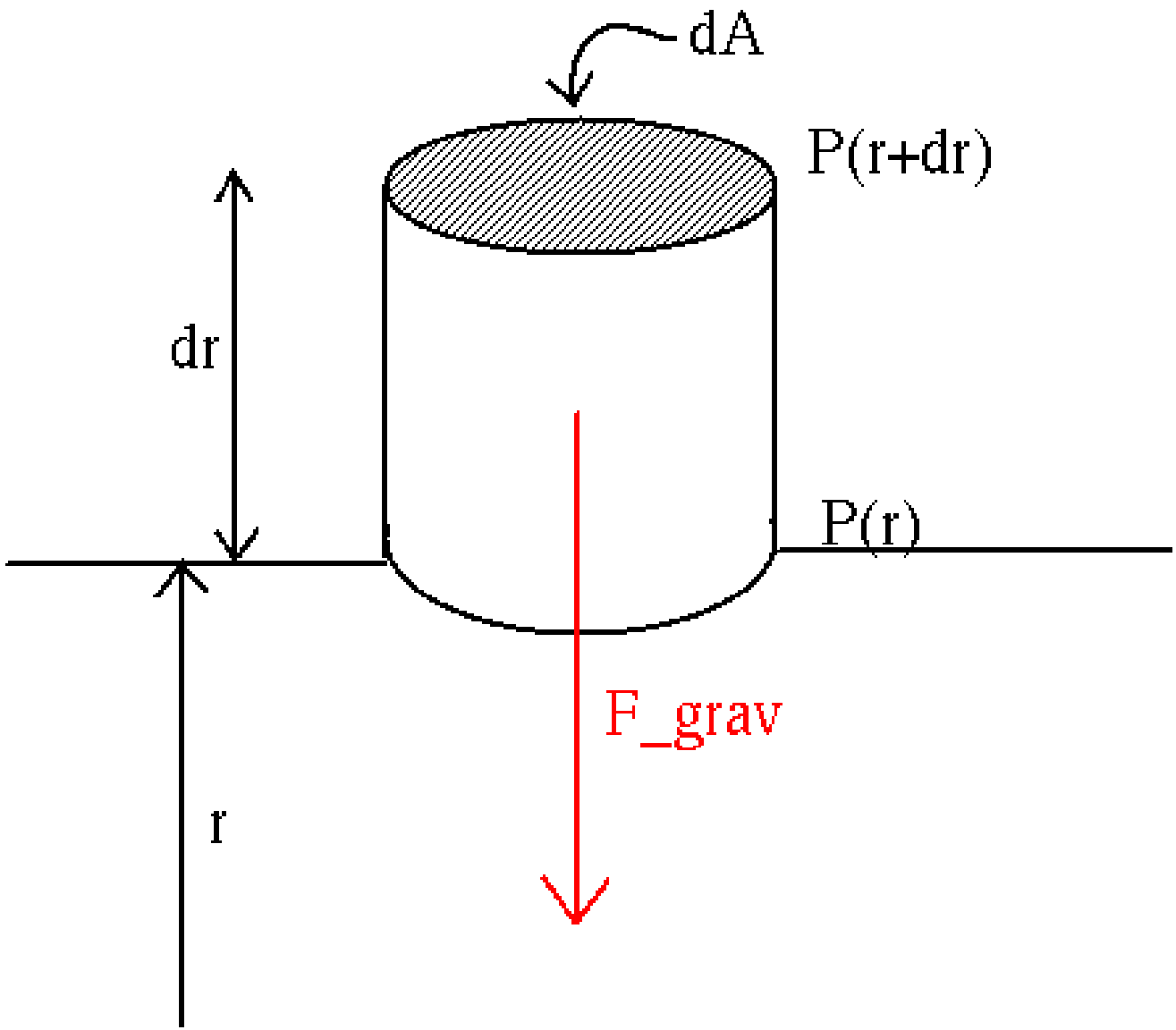
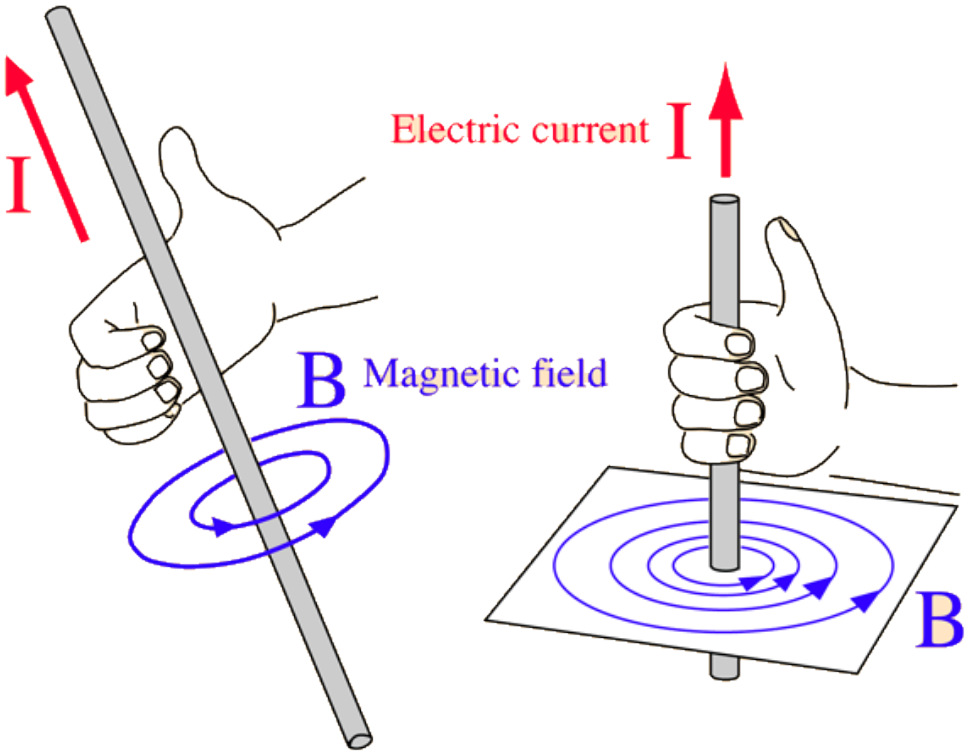


$$\frac{dP}{dr} = -\rho g$$

Only changes in P give Force

Quick Aside: Magnetic Pressure



$$P_{\rm mag} = B^2/2\mu_0$$

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- Beyond the atmosphere is the vacuum of space, much less material means lower pressure
- Pressure difference means particles escape

Practice Problem: Solar Wind Mass Loss

Satellites in orbit around the Earth constantly measure the solar wind. They find that the solar wind is mainly composed of protons with a velocity of $v \approx 500$ km/sec and a number density of about $n \approx 7$ cm^{-3}.

$M_\odot = 2 \times 10^{30}$ kg $\qquad$ $m_p = 1.67 \times 10^{-27}$ kg

- How much mass is lost due to the solar wind, in $M_\odot$/yr?
- How many years until the Sun loses all of its mass?

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- What is the mass element $\mathrm{d}M$ for a thin spherical shell?

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- How much mass is lost? $\approx 2.6 \times 10^{-14}$ $M_\odot$/yr
  - $\mathrm{d}M = \rho \mathrm{d}V = \rho 4\pi r^2 \mathrm{d}r = mn4\pi r^2 \mathrm{d}r$
  - $\mathrm{d}M/\mathrm{d}t = mn4\pi r^2 \mathrm{d}r/\mathrm{d}t$
- How many years until it's all lost? $\approx 3.9 \times 10^{13}$ yr
  - $t = M/\left(\mathrm{d}M/\mathrm{d}t\right)$