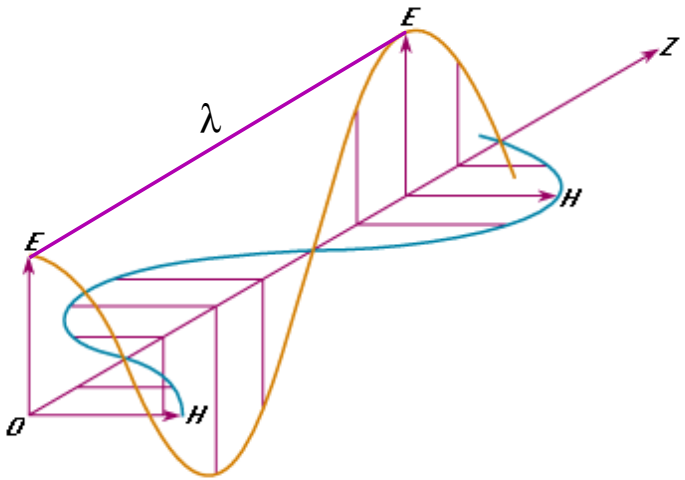
Characteristics of "free" em. Waves

- electric and magnetic fields oscillate $\perp$ to direction of propagation $\Rightarrow$ **transverse waves**
- $\vec{E} \perp \vec{B}$ are in phase
- phase velocity: $c = 1/\sqrt{\mu_0 \epsilon_0} =$ **speed of light**
- dispersion relation: $\omega = 2\pi f = c|\vec{k}|$ or $\lambda = cT$ $(|\vec{k}| = 2\pi/\lambda$.
- sources (not explained in this course)
  - accelerated charged particles =
  - **time-dependent** electric charges and and currents
  - modern picture: quantum-mechanical transitions in atoms (visible light, UV) and nuclei (γ rays)



The em. spectrum

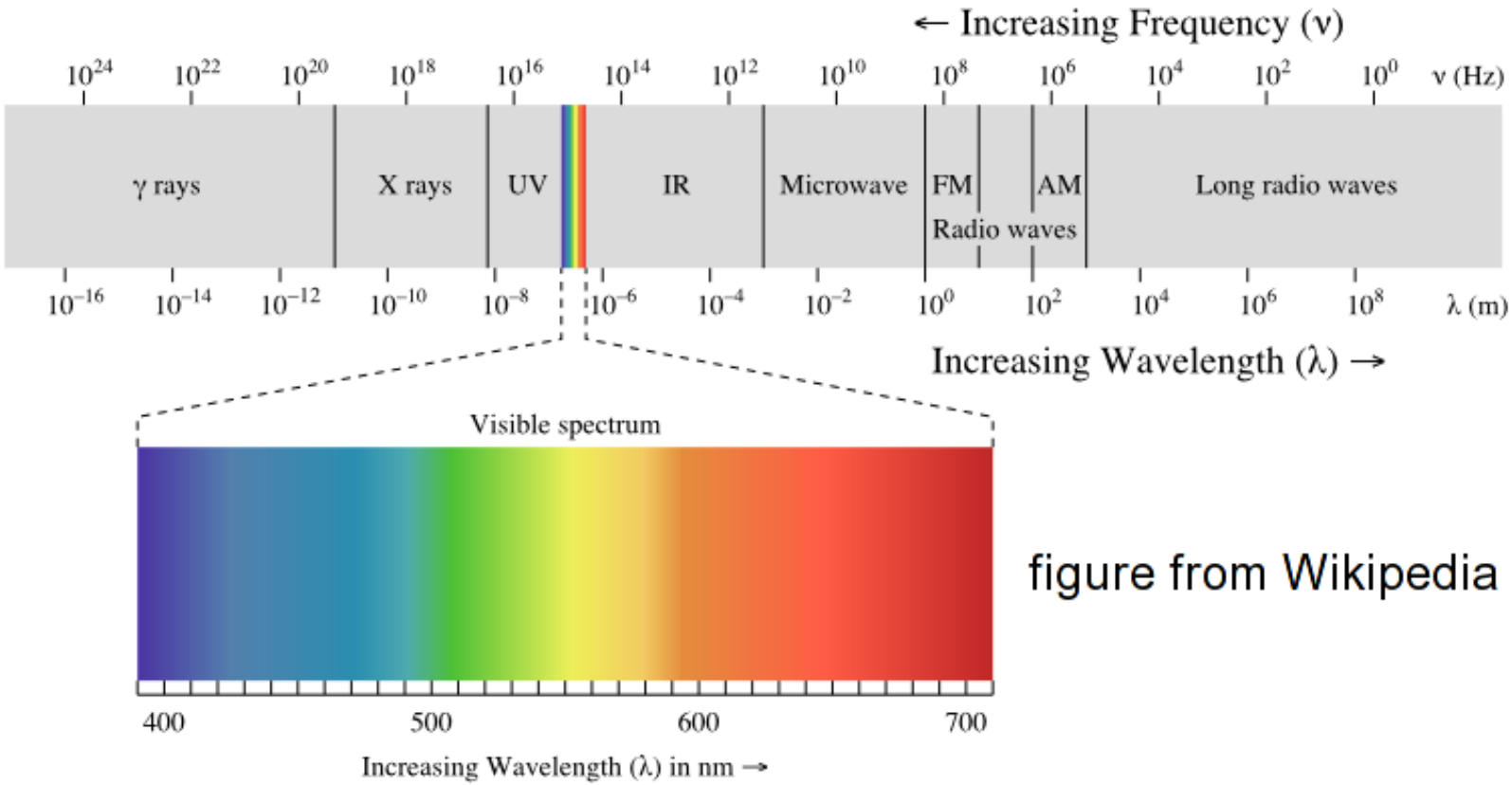


figure from Wikipedia

The em. spectrum

	f (Hz)	λ (m)	source (ex.)
γ rays	$> 10^{20}$	$< 10^{-12}$	radioactivity, nuclear transitions
X rays	$> 3 \cdot 10^{16}$	$< 10^{-8}$	bremsstrahlung radiation, atomic transitions
UV	$7.5 \cdot 10^{14}$-$3 \cdot 10^{16}$	$4 \cdot 10^{-7}$ - 10^{-8}	our Sun
visible light	$4 \cdot 10^{14}$-$7.5 \cdot 10^{14}$	$4 \cdot 10^{-7}$ - $7.5 \cdot 10^{-7}$	atomic transitions
infrared	$3 \cdot 10^{11}$ - $4 \cdot 10^{14}$	10^{-3}-$7.5 \cdot 10^{-7}$	transitions between vibrational modes of molecules

The em. spectrum

	f (Hz)	λ (m)	source (ex.)
Millimeter Waves	$30\text{-}300 \cdot 10^9$	$10^{-3}\text{-}10^{-2}$	antenna
microwaves	$1.6\text{-}30 \cdot 10^9$	$10\text{-}187 \cdot 10^{-3}$	magnetrons (microwave oven), rotation and torsion transitions of molecules, cosmic microwave backgrond
radio waves	$5 \cdot 10^5\text{-}1.6 \cdot 10^9$	$0.2\text{-}200$	antenna