

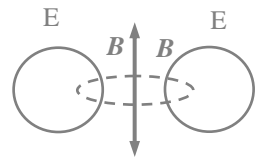
Chapter 7 Electromagnetic Wave

7.1 Displacement Current

7.2 The Generation & Travel of EMW

7.3 The Fundamental Properties of EMW

7.4 Electromagnetic Spectrum

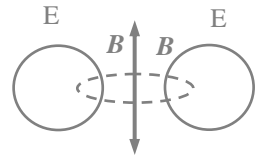


7.4 Electromagnetic Spectrum

- Maxwell's equations impose no limit on the frequency of electromagnetic waves.
- It extends continuously from the long radio waves to the very high energy gamma rays observed in cosmic radiation.

$$f: 10-10^{24}\text{Hz}; \lambda: 10^7-10^{-16}\text{m}$$

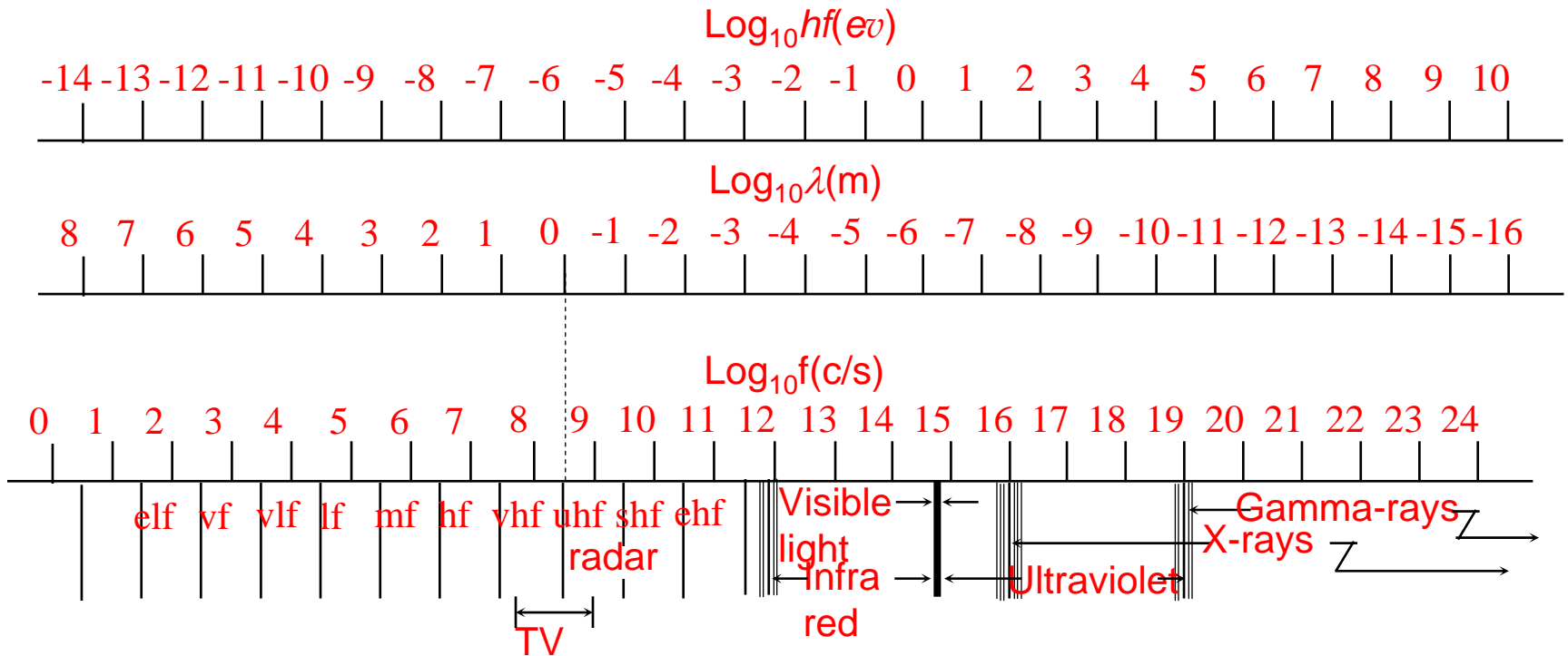
- The frequencies of long radio waves are about 10 hertz, and the wavelengths are about 3×10^7 m
- The frequencies of gamma rays are of the order of 10^{24} hertz, and the wavelengths of the order of 3×10^{-16} meter.



7.4 Electromagnetic Spectrum

Band Numbers	Frequency Range	Metric Subdivision (米细分)	Abbreviation
1	3-30Hz		
2	30-300 Hz	Megametric waves 10^6	Elf极低频
3	300-3000 Hz		vf 音频
4	3-30 kHz	Myriametric waves 10^4	Vlf甚低频
5	30-300kHz	Kilometric waves 10^3	lf 低频
6	300-3000 kHz	Hectometric waves 10^2	Mf中频
7	30-300 MHz	Decametric waves 10^1	hf高频
8	300-3000 MHz	Metric waves 10^0	Vhf甚高频
9	300-3000 MHz	Decimetric waves 10^{-1}	Uhf特高频
10	3-30GHz	Centimetric waves 10^{-2}	Shf超高频
11	30-300GHz	Millimetric waves 10^{-3}	Ehf极高频
12	300-3000GHz	Decimillimetric waves 10^{-4}	

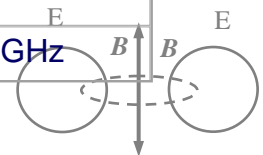
7.4 Electromagnetic Spectrum

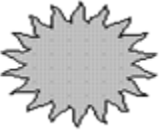


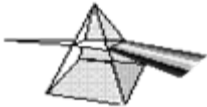



The spectrum of electromagnetic waves. The abbreviations elf, vf, vlf, . . . mean, respectively, extremely low frequency, voice frequency, very low frequency, low frequency, medium frequency, high frequency, very high frequency, ultrahigh frequency, super high frequency, and extremely high frequency. The limits indicated by the shaded regions are approximate. The energy hf , where h is Planck's constant (6.63×10^{-34} joule-second) and f is the frequency, is the energy of a photon or quantum of radiation.

7.4 Electromagnetic Spectrum




Region	Approx Range (meters/hertz)	Specific Range
Radio Waves	$10^4 - 10^{-2}$ m/ $10^4 - 10^{10}$ Hz	
	ultra-low frequency (ULF)	3 - 30 Hz
	extremely low frequency (ELF)	30 - 300 Hz
	voice frequencies (VF)	300 Hz - 3 kHz
	very low frequency (VLF)	3 - 30 kHz
	low frequency (LF)	30 - 300 kHz
	medium frequency (MF)	300 kHz - 3 MHz
	high frequency (HF)	3 - 30 MHz
	very high frequency (VHF)	30 - 300 MHz
	ultra high frequency (UHF)	300 MHz - 3 GHz
	super high frequency (SHF)	3 - 30 GHz
	extremely high frequency (EHF)	30 - 300 GHz
	Shortwave	see MF, HF
	Television	see VHF, UHF
Microwave	30 cm - 1 mm/1-300 GHz	



Infrared 	$10^{-3} - 10^{-6} \text{ m} / 10^{11} - 10^{14} \text{ Hz}$	
	Far	1000-30 μm  Infrared Guidance
	Middle	30-3 μm
	Near	3-0.75 μm  Infrared Guidance
Visible 	$5 \times 10^{-7} \text{ m} / 2 \times 10^{14} \text{ Hz}$	
	red	770-622 nm
	orange	622-597 nm
	yellow	597-577 nm
	green	577-492 nm
	blue	492-455 nm
	violet	455-390 nm

Ultraviolet 	$10^{-7} - 10^{-8} \text{ m} / 10^{15} - 10^{16} \text{ Hz}$	
	UV-A (least harmful)	400-315 nm
	UV-B (more harmful, absorbed by ozone)	315-280 nm
	UV-C (most harmful, but all absorbed by air)	280-100 nm
	Near-UV ("black light")	400-300 nm
	Mid-UV	300-200 nm
	Far-UV (vacuum)	200-100 nm
	Extreme – UV	100-10 nm

X ray 	$10^{-9} - 10^{-11} \text{ m} / 10^{17} - 10^{19} \text{ Hz}$	 dinosaur and human coexistence
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Gamma ray 	$10^{-11} - 10^{-13} \text{ m} / 10^{19} - 10^{21} \text{ Hz}$	 Principle of γ -knife  γ -knife
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