

Scales for temperature, energy, frequency, time, length and mass are related through constants:  
 $k$  (13.807 yJ/K),  $e$  (160.218 zC),  $h$  (662.608 uJ s),  $c$  (299792458 m/s),  $G$  (66.742 m<sup>3</sup>/s<sup>2</sup> Pg).  
 Planck values are indicated in the third row and the age of the universe is in the right column.

| Temp.        | Volt         | Energy                                    | Freq.        | Time            | Length          | Mass         | Age of U      |
|--------------|--------------|-------------------------------------------|--------------|-----------------|-----------------|--------------|---------------|
| kelvin       | eV           | joule                                     | hertz        | second          | metre           | kilogram     | second        |
| $10^{32.55}$ | $10^{28.49}$ | $10^{9.69}$                               | $10^{42.87}$ | $10^{-42.87}$   | $10^{-34.39}$   | $10^{-7.26}$ | $10^{-42.87}$ |
|              |              | GJ                                        | $10^{42}$    | $10^{-42}$      |                 |              | $10^{-42}$    |
| WK           | XeV          |                                           |              |                 | vm              | mg           |               |
|              |              | MJ                                        | $10^{39}$    | $10^{-39}$      |                 |              |               |
| XK           | YeV          |                                           |              |                 | wm              | g            | us            |
|              |              | kJ                                        | UHz          | us              |                 |              |               |
| YK           | ZeV          |                                           |              |                 | $G c^{-2}$      | ..... kg     | ws            |
|              |              | J                                         | VHz          | vs              |                 |              |               |
| ZK           | EeV          |                                           |              |                 | ym              | Mg           | ys            |
|              |              | mJ                                        | WHz          | ws              |                 |              |               |
| EK           | PeV          |                                           |              |                 | zm              | Gg           | as            |
|              |              | LHC $\mu$ J                               | XHz          | xs              |                 |              |               |
| PK           | TeV          |                                           |              |                 | 2000 am         | Tg           | ps            |
|              |              | W, Z $\tau$ nJ                            | YHz          | ys              |                 |              |               |
| TK           | GeV          | p, n $\mu$ pJ                             | ZHz          | zs              | 1950 fm         | Pg           | $\mu$ s       |
|              |              | $\nu_\tau$ $\downarrow$ e <sup>-</sup> fJ |              |                 |                 |              |               |
| GK           | MeV          | $\nu_\mu$ $\downarrow$                    |              | $\gamma$ -ray   | 1935 pm         | Eg           | s             |
|              |              |                                           |              |                 |                 |              |               |
| MK           | keV          |                                           | EHz          | X-ray as        | 1900 nm         | Zg           | Ms            |
|              |              |                                           |              | Soft UV         |                 |              |               |
|              |              | aJ                                        | PHz          | Near IR         | visible $\mu$ m | Yg           | Ts            |
| kK           | eV           | ..... e                                   |              | Far             | thermal         |              |               |
|              |              | $\nu_e$ $\downarrow$ zJ                   | THz          |                 |                 |              |               |
| CMB          | meV          |                                           |              |                 | mm              | Xg           | Es            |
|              |              | ..... k                                   |              | $\mu$ -wave SHF |                 |              |               |
| K            | .....        |                                           |              | UHF             | ns              |              |               |
|              |              | yJ                                        | GHz          | VHF             |                 | Wg           | Ys            |
| mK           | $\mu$ eV     |                                           |              | HF              | radio           |              |               |
|              |              | xJ                                        | MHz          | MF $\mu$ s      |                 |              |               |
|              |              |                                           |              | LF              | km              | Vg           | Ws            |
| $\mu$ K      | neV          |                                           |              |                 |                 |              |               |
|              |              | wJ                                        | kHz          | trebl ms        | au-di-b-le Mm   | Ug           | Us            |
| nK           | peV          |                                           |              |                 |                 |              |               |
|              |              | $\gamma$ $\downarrow$ h                   | ..... Hz     | s               | ..... c         |              | $10^{42}$     |

zepto:  $10^{-21}$ , yocto:  $10^{-24}$ , xenno:  $10^{-27}$ , wadeko?  $10^{-30}$ , vendeko:  $10^{-33}$ , udodeko?  $10^{-36}$ .  
 zetta:  $10^{+21}$ , yotta:  $10^{+24}$ , xenna:  $10^{+27}$ , wadeka?  $10^{+30}$ , vendeka:  $10^{+33}$ , udodeka?  $10^{+36}$ .

# The Electromagnetic Spectrum and some Radio Frequency Bands

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|                           |     |      |    |                                       |
|---------------------------|-----|------|----|---------------------------------------|
| 1                         | Hz  | 300  | Mm | Delta up to 4Hz - Sleep               |
| 4                         | Hz  | 75   | Mm | Theta 4 to 7Hz - Day-dreaming         |
| 8                         | Hz  | 40   | Mm | Alpha 8 to 14 - Receptive             |
| 15                        | Hz  | 20   | Mm | Beta above 15 - Very alert            |
| 20                        | Hz  | 15   | Mm | Audible lower limit                   |
| 440                       | Hz  | 682  | km | Musical note A                        |
| 20                        | kHz | 15   | km | Audible upper limit                   |
| 137                       | kHz | 2.2  | km | Euro band                             |
| $153 + 9(n-1) = 9(16+n),$ |     |      |    | Long Wave: $n = 1, 2, 3, \dots, 15$   |
| 279                       | kHz | 1075 | m  | Long Wave: ends with channel 15       |
| $288 + 9(n-1) = 9(30+n),$ |     |      |    | Navigation $n = 1, 2, 3, \dots, 27$   |
| $531 + 9(n-1) = 9(58+n),$ |     |      |    | Medium Wave $n = 1, 2, 3, \dots, 120$ |
| 1602                      | kHz | 187  | m  | Medium Wave: ends at channel 120      |
| 2450                      | MHz | 122  | mm | Microwave oven                        |
| 3                         | GHz | 100  | mm | Radar                                 |
| 10                        | GHz | 30   | mm | Satellite TV                          |
| 160                       | GHz | 2    | mm | Cosmic Microwave Background           |
| 20                        | THz | 15   | um | Infra-Red rays                        |
| 441                       | THz | 680  | nm | Visible red light                     |
| 714                       | THz | 420  | nm | Visible violet light                  |
| 1000                      | THz | 300  | nm | Ultra-Violet rays                     |
| 30                        | PHz | 10   | nm | X-rays from electron processes        |
| 30                        | EHz | 10   | pm | Gamma rays from atomic nuclei         |
| 1                         | XHz | 300  | zm | Gamma rays from the Crab Nebula       |