More Precisely... Astronomical Measurement

Astronomers use many different kinds of units in their work, simply because no single system of units will do. Rather than the *Système Internationale* (SI), or meter-kilogram-second (MKS), metric system used in most high school and college science classes, many professional astronomers still prefer the older centimeter-gram-second (CGS) system. However, astronomers also commonly introduce new units when convenient. For example, when discussing stars, the mass and radius of the Sun are often used as reference points. The solar mass, written as $M_{\odot}$, is equal to 2.0×10^{33} g, or 2.0×10^{30} kg (since 1 kg = 1000 g). The solar radius, $R_{\odot}$, is equal to 700,000 km, or 7.0×10^{8} m (1 km = 1000 m). The subscript $\odot$ always stands for Sun. Similarly, the subscript $\oplus$ always stands for Earth. In this book, we will use the units that astronomers commonly use in any given context, but we will also give the "standard" SI equivalents where appropriate.

Of particular importance are the units of length astronomers use. On small scales, the *angstrom* (1 Å $= 10^{-10}$ m $= 10^{-8}$ cm), the *nanometer* (1 nm = 10^{-9} m = 10^{-7} cm), and the *micron* (1 μm = 10^{-6} m = 10^{-4} cm) are used. Distances within the solar system are usually expressed in terms of the *astronomical unit* (A.U.), the mean distance between Earth and the Sun. One A.U. is approximately equal to 150,000,000 km, or 1.5×10^{11} m. On larger scales, the *light year* (1 ly = 9.5×10^{15} m = 9.5×10^{12} km) and the *parsec* (1 pc = 3.1×10^{16} m = 3.1×10^{13} km = 3.3 ly) are commonly used. Still larger distances use the regular prefixes of the metric system: *kilo* for one thousand and *mega* for one million. Thus, 1 *kiloparsec* (kpc) = 10^{3} pc = 3.1×10^{19} m, 10 megaparsecs (Mpc) = 10^{7} pc = 3.1×10^{23} m, and so on.

Astronomers use units that make sense within a context, and as contexts change, so do the units. For example, we might measure densities in grams per cubic centimeter (g/cm^{3}), in atoms per cubic meter (atoms/m^{3}), or even in solar masses per cubic megaparsec ($M_{\odot}$/Mpc^{3}), depending on the circumstances. The important thing to know is that once you understand the units, you can convert freely from one set to another. For example, the radius of the Sun could equally well be written as $R_{\odot} = 6.96 \times 10^{8}$ m, or 6.96×10^{10} cm, or 109 $R_{\oplus}$, or 4.65×10^{-3} A.U., or even 7.36×10^{-8} ly—whichever happens to be most useful. Some of the more common units used in astronomy, and the contexts in which they are most likely to be encountered, follow.

Tabela 1 – Unidades e Medidas Astronômicas

Length:

1 angstrom (Å)	$= 10^{-10}$ m	atomic physics, spectroscopy
1 nanometer (nm)	$= 10^{-9}$ m	
1 micron (μm)	$= 10^{-6}$ m	interstellar dust and gas
1 centimeter (cm)	= 0.01 m	in widespread use throughout all astronomy
1 meter (m)	= 100 cm	
1 kilometer (km)	$= 1000$ m $= 10^5$ cm	
Earth radius ($R_\oplus$)	= 6378 km	planetary astronomy
Solar radius ($R_\odot$)	$= 6.96 \times 10^8$ m	solar system, stellar evolution
1 astronomical unit (A.U.)	$= 1.496 \times 10^{11}$ m	
1 light year (ly)	$= 9.46 \times 10^{15}$ m	
	= 63,200 A.U.	galactic astronomy, stars and star clusters
1 parsec (pc)	$= 3.09 \times 10^{16}$ m	
	= 3.26 ly	
1 kiloparsec (kpc)	= 1000 pc	galaxies, galaxy clusters, cosmology
1 megaparsec (Mpc)	= 1000 kpc	

Mass:

1 gram (g)		in widespread use in many different areas
1 kilogram (kg)	= 1000 g	
Earth mass ($M_\oplus$)	$= 5.98 \times 10^{24}$ kg	planetary astronomy
Solar mass ($M_\odot$)	$= 1.99 \times 10^{30}$ kg	"standard" unit for all mass scales larger than Earth

Time:

1 second (s)		in widespread use throughout astronomy
1 hour (h)	= 3600 s	planetary and stellar scales
1 day (d)	= 86400 s	
1 year (yr)	$= 3.16 \times 10^7$ s	virtually all processes occurring on scales larger than a star

Tabela 2 – Constantes Úteis e Medidas Físicas

astronomical unit	1 A.U. = 1.496×10^8 km (1.5×10^8 km)
light year	1 ly = 9.46×10^{12} km (10^{13} km; 6 trillion miles)
parsec	1 pc = 3.09×10^{13} km = 3.3 ly
speed of light	c = 299,792.458 km/s (3×10^5 km/s)
Stefan-Boltzmann constant	σ [Greek sigma] = 5.67×10^{-8} W/m$^2 \cdot$ K^4
Planck's constant	$h = 6.63 \times 10^{-34}$ Js
gravitational constant	$G = 6.67 \times 10^{-11}$ Nm^2/kg^2
mass of the Earth	$M_\oplus = 5.97 \times 10^{24}$ kg (6×10^{24} kg; about 6000 billion billion tons)
radius of the Earth	$R_\oplus$ = 6378 km (6500 km)
mass of the Sun	$M_\odot = 1.99 \times 10^{30}$ kg (2×10^{30} kg)
radius of the Sun	$R_\odot = 6.96 \times 10^5$ km (7×10^5 km)
luminosity of the Sun	$L_\odot = 3.90 \times 10^{26}$ W
effective temperature of the Sun	$T_\odot$ = 5778 K (5800 K)
Hubble constant	$H_0 \approx$ 75 km/s/Mpc
mass of the electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of the proton	$m_p = 1.67 \times 10^{-27}$ kg

**The rounded-off values used in the text are shown in parentheses.*

Conversions between English and Metric Units

1 inch	=	2.54 centimeters (cm)	1 mile	=	1.609 kilometers (km)
1 foot (ft)	=	0.3048 meters (m)	1 pound (lb)	=	453.6 grams (g) or .4536 kilograms (kg) (on Earth)

Outras Escalas e Medidas Utéis

- Distancias: U.A, a.l, pc, Kpc (10^3), M (10^6)pc

- Unidades de tempo: Mega-ano = My (10^6), Giga-ano = Gy (10^9)

- Unidades de Energia e seus Múltiplos:

Eletron- volt (eV) - é a quantidade de energia cinética ganha por um único elétron quando acelerado por uma diferença de potencial elétrico de um volt, no vácuo.

1 eV = 1,602 177 33 (49) x 10^{-19} joules.

1 keV (quilo eV): mil elétrons-volt = 10^3 elétrons-volt (eV)

1 MeV (mega eV): 1 milhão de elétrons-volt = 10^6 eV

1 GeV (giga eV): 1 bilhão (mil milhões) de elétrons-volt = $10^{9\,(eV)}$

1 TeV (tera eV): 1 trilhão (mil bilhões) de elétrons-volt = 10^{12} (eV)

Anexo:

Lembrando algumas propriedades de Potência e Logarítmo

...que usaremos durante todo o curso

Se: $10^x = y$ então: $x = \log y$

Logarítmo (x) de um número (y) é o expoente ao qual se deve elevar 10 para se obter o número (y) dado.

$10^0 = 1$ por definição
$10^1 = 10$
$10^2 = 10 \times 10 = 100$
$10^3 = 10 \times 10 \times 10 = 1000$

$0 = \log 1$
$1 = \log 10$
$2 = \log 100$
$3 = \log 1000$

Propriedades

$$\log(a \cdot b) = \log \mathbf{a} + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log a^n = \mathbf{n} \cdot \log a$$