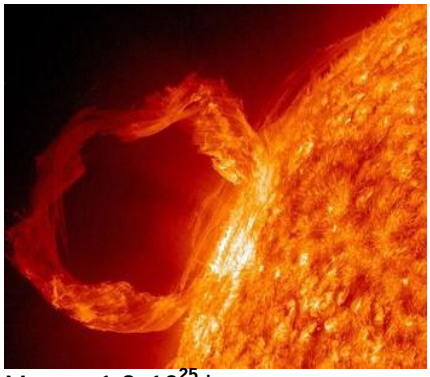
Mass = 9.5×10^{31} kg
Volume = 5.0×10^{47} m^3

Mass = 5.1×10^{18} kg
Volume = 4.2×10^{18} m^3



Mass = 1.2×10^{25} kg
Volume = 6.0×10^{28} m^3

Mass = 2.0×10^{39} kg
Volume = 1.6×10^{60} m^3

In addition to mass and volume, density is the next most important feature of matter that we can easily determine. Density is just the mass of an object divided by its volume. Although density is usually given in terms of the unit kilograms/meter^3, in astronomy we prefer to use the number of particles per cubic meter. It is easy to imagine how a cubic meter might contain 1000 atoms, but the equivalent density of 1.6×10^{-24} kg/m^3 seems mysterious and doesn't provide much of a clue for how to think about it physically!

Problem 1 – Complete the table below by calculating the density of each astronomical object in terms of atoms per cubic meter.

Name	Volume (m^3)	Mass (kg)	Density (atoms/m^3)
Atmosphere of Earth	4.2×10^{18}	5.1×10^{18}	
Red supergiant star	2.3×10^{33}	4.0×10^{31}	
Surface of our Sun	6.0×10^{28}	1.2×10^{25}	
Atmosphere of Moon	1.9×10^{15}	1.0×10^{4}	
Solar Corona	9.0×10^{26}	8.9×10^{13}	
Interstellar Cloud	5.0×10^{47}	9.5×10^{31}	
Orion Nebula	6.2×10^{51}	1.5×10^{33}	
Solar Wind	1.4×10^{34}	4.5×10^{14}	
Milky Way galaxy	1.6×10^{60}	2.0×10^{39}	
Van Allen radiation belts	1.3×10^{23}	1.1×10^{-2}	

Problem 1 – Complete the table below by calculating the density of each astronomical object in terms of atoms per cubic meter.

Answer: example Solar Corona:

$D = M/V = 8.9 \times 10^{13}$ kg/9.0×10^{26} m^3 = 9.9×10^{-14} kg/m^3

$N = 9.9 \times 10^{-14} / 1.6 \times 10^{-27} = 6.2 \times 10^{13}$ atoms/m^3

Name	Volume (m^3)	Mass (kg)	Density (atoms/m^3)
Atmosphere of Earth	4.2×10^{18}	5.1×10^{18}	7.5×10^{26}
Red supergiant star	2.3×10^{33}	4.0×10^{31}	1.1×10^{25}
Surface of our Sun	6.0×10^{28}	1.2×10^{25}	1.3×10^{23}
Atmosphere of Moon	1.9×10^{15}	1.0×10^{4}	3.3×10^{15}
Solar Corona	9.0×10^{26}	8.9×10^{13}	6.2×10^{13}
Interstellar Cloud	5.0×10^{47}	9.5×10^{31}	1.2×10^{11}
Orion Nebula	6.2×10^{51}	1.5×10^{33}	1.5×10^{8}
Solar Wind	1.4×10^{34}	4.5×10^{14}	2.0×10^{7}
Milky Way galaxy	1.6×10^{60}	2.0×10^{39}	8.1×10^{4}
Van Allen radiation belts	1.3×10^{23}	1.1×10^{-2}	53

Students can also be asked to compare how many times more dense is Object A than Object B? Example: Atmosphere of Moon / Milky Way galaxy = $3.3 \times 10^{15} / 8.1 \times 10^{4}$ = 41 billion times!