THE AVERAGE DENSITY OF SOLAR SYSTEM

First we find and summarize various data about the six nearest stars with respect to our Sun. We are interested in average distances from the stars to the Sun. Table 1 reveals data from [1]

Star	Distance (in light years)
Proxima Centauri	*4.24 ly*
α Centauri A,B (binary star)	*4.36 ly*
Barnard's Star	*5.96 ly*
Wolf 359	*7.78 ly*
Lalande 21185	*8.29 ly*
Sirius A,B (binary star)	*8.58 ly*

Table 1. List of nearest stars.

Now we calculate the average distance:

$$\text{average distance} = \frac{4.24+4.36+5.96+7.78+8.29+8.58}{6} ly = 6.54\, ly$$

We assume the Solar System is a sphere of diameter half this average distance:

$$\mathrm{D} = \frac{6.54}{2} ly = 3.27\, ly$$

Recall that $1\, ly = 9.46 \times 10^{15} m$, then we obtain diameter in metric:

$$\mathrm{D} = 3.27 \times 9.46 \times 10^{15} m = 3.09 \times 10^{16} m$$

The volume of sphere of radius $R = \frac{D}{2}$ equals

$$V = \frac{4}{3}\pi R^3 = \frac{\pi}{6} D^3 = \frac{3.14}{6}\left(3.09 \times 10^{16} m\right)^3 = 1.54 \times 10^{49} m^3$$

Now we calculate the approximate mass of Solar system. We assume that masses less than 0.01% of the (Sun + planets + moons) may be neglected. We use following data from [2]

Object	Mass, kg
Sun	*1.99 10^{30}*
Jupiter (with moons)	*1.90 10^{27}*
Saturn(with moons)	*5.68 10^{26}*
Uranus(with moons)	*8.68 10^{25}*
Neptune(with moons)	*1.02 10^{26}*
Earth(with moons)	*5.97 10^{24}*
Venus	*4.87 10^{24}*
Mars(with moons)	*6.42 10^{23}*
Mercury	*3.30 10^{23}*
Pluto(with moons)	*1.31 10^{22}*

Suns+planets+moons $\Rightarrow 1.99\cdot10^{30}+1.90\cdot10^{27}+5.68\cdot10^{26}+8.68\cdot10^{25}+1.02\cdot10^{26}+2$

$+5.97\times10^{24}+4.87\times10^{24}+6.42\times10^{23}+3.30\times10^{23}+1.31\times10^{22}=1.993\times10^{30}\,kg$

we may neglect (see [3],[4]):

- Kuiper belt. *1.8 10^{26}kg (estimated value),* $\dfrac{1.8\times10^{26}}{1.993\times10^{30}}=9\times10^{-5}<0.01\%$

Oort Cloud objects *3 10^{25} kg(estimated value),* $\dfrac{3\times10^{25}}{1.993\times10^{30}}=1.5\times10^{-5}<0.01\%$

interstellar gases mass is less than 0.01% of Sun mass
Comets gives approximately 0.01% of mass (see [5])

Now we calculate average density as the mass per volume:

$$\rho=\frac{M}{V}=\frac{2\times10^{30}\,kg}{1.54\times10^{49}\,m^3}=1.294\cdot10^{-19}\,\frac{kg}{m^3}=1.294\cdot10^{-22}\,\frac{g}{cm^3}\approx1.3\cdot10^{-22}\,\frac{g}{cm^3}$$

The physical meaning of such a small value is the fact that almost all the space of solar system consists of so called physical vacuum.

References

[1] - List of nearest stars, http://en.wikipedia.org/wiki/List_of_nearest_stars
[2] - List of Solar System objects by size, http://en.wikipedia.org/wiki/
List_of_Solar_System_objects_by_size
[3] – Kuiper belt, http://en.wikipedia.org/wiki/Kuiper_belt
[4] – Oort cloud, http://en.wikipedia.org/wiki/Oort_cloud
[5] – Composition Of The Solar System, http://www.solarviews.com/eng/solarsys.htm