Re: ILE − The Ideal Lane−Emden Equation

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* *From*: af250@xxxxxxxxxxxxxxxxxxx (John Park)
* *Date*: 21 Jul 2008 10:12:59 GMT

Thomas Smid (thomas.smid@xxxxxxxxx) writes:

> On 20 Jul, 13:32, af...@xxxxxxxxxxxxxxxxxxx (John Park) wrote:
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> > Thomas Smid (thomas.s...@xxxxxxxxx) writes:
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> > [...]
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> > > > > the radii for the hydrogen masses in the solar system (Sun, Jupiter, Saturn, Uranus, Neptune) follow the sequence 1, 0.1, 0.085, 0.037, 0.035, which quite accurately corresponds to an exponent 1/3 in the mass−radius relationship, but not to any of those claimed above.

I replied:

> Something to do with the
> fact that they're not doing
> nuclear fusion?

> More to the point, you treat these five bodies
> as though they were
> analogous despite the facts that: one has a
> surface temperature a good
> 5500 K greater than the others; in four the
> hydrogen is present as
> molecules or a metallic phase, while in the
> other it is monatomic or in a
> plasma; and in two cases hydrogen probably
> makes up only about 15% of
> the total mass anyway.

It is in the first place a hard observational fact that the radius for
these bodies follows a R~M^1/3 law. Whatever you make out of this
with regard to their physics has to be consistent with it. It
definitely suggests that the radial density function is pretty much
identical in all cases (if you assume an ideal gas in hydrostatic

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equilibrium, then (as shown above) the radius is given by R=[M(R)*(3−
k)/4pi/n(R)/m]^1/3 , where k is the power index for the radial
density function n(r)~r^−k ; the figures show that k differs not by
more than about 10% between the sun and the hydrogen planets (Saturn
excluded for some reason)); so even if there is any fusion occurring
in the sun, it has an insignificant effect on its structure).

But it's pretty clearly not the _same_ ideal gas (plasma/H vs H2/CH4 &c); and
for the outer planets it's questionable whether it makes sense to regard them as gases at all.

I think it makes sense to describe all these planets as consisting largely of an ideal gas, because even for Neptune, the internal temperature (as given by the gravitational potential over the virial theorem) is still about 15,000 K, which should make it impossible for

Could you elaborate on that? What I've read suggest that the outer planets are mostly slushes (with rocky cores). Which "virial theorem" are you referring to, the one relating kinetic and potential energies?

organized structures of the matter in the form of a fluid or a solid to develop. So essentially, we are still dealing here (like in the case of the sun) with a 'plasma soup' of nuclei and electrons. Because no atoms (and thus no excitation of atomic transitions) can exist at this temperature and density, one can consider it as an ideal gas (in fact more ideal than gases in the usual sense).

You've enough data to find a coincidence;
not enough to show a connection. (Note that Uranus and Neptune are so similar they're effectively the same point.)

Well, the point is that these 'coincidences' confirm a mass−radius relationship R~M^1/3, but invalidate other exponents.

They don't confirm anything. They suggest a mass−radius relationship, which, if true, would imply that all other variables, such as composition, temperature and thermonuclear activity, have no effect. That is counter−intuitive, to say the least.

There must be lots of stellar mass/radius data from eclipsing binaries. Why don't you use those results?

Put it another way: if Uranus and Neptune had the same masses but were 75%
hydrogen instead of 15% and had orbits inside Venus', would you still expect them to fit your curve?

The fact that they fit the curve suggests that they *do* consist

> largely of hydrogen.

You haven't got nearly enough data to claim that.

> By the way, the smaller planets also follow a R~M^1/3 law for themselves, but have a consistently smaller radius by about a factor 0.6 (Mars 0.7) (this agrees with their higher average density compared to the sun and giant planets).

So the 1/3 power law applies to rocky bodies as well as ideal gases? How do you rationalise that?

−−John Park

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