

## The equations from the interview with Andrew Prentice

Episode 9 – 9 April 2009

These equations are all about proportionality, which means that you can't use them for exact calculations, they just tell you that the left hand side depends on the right hand side. They don't give you any actual numbers. The use of proportionalities is that you don't have to worry about going through all the nasty detail just to get to the main idea.

The symbol  $\propto$  is used to signify proportionality.

1. Label each planet by its order from the sun. So Earth would be 3, Mars is 4, Jupiter 5 etc... Call a general planet  $N$ , where  $N$  goes from 1 to 8 (for the 8 planets; let's not hear any more about Pluto). Let  $T_N$  be the temperature of planet  $N$ , and let  $R_N$  be the distance of planet  $N$  from the sun (ie. its orbital radius). So  $T_3$  means the temperature of Earth, etc. It was experimentally seen that

$$T_N \propto \frac{1}{R_N}$$

which means that the temperature is proportional to the inverse of the distance.

In other words, if a planet is further from the sun, it's colder.

2. Let  $r$  be the universal gas constant – its value is unimportant since we are just talking about proportionality. BE AWARE: This  $r$  is totally different to  $R_N$ .  $R_N$  is a distance and  $r$  is some other thing that isn't distance. We're only using the same letter to keep consistent with what Andrew said. Let  $H_N$  be the thermal energy of a ring that later forms the  $N$ th planet, then

$$H_N \propto r \times T_N$$

where  $T_N$  is again the temperature. But since  $r$  is just a constant the temperature is the really important bit and so we can write:

$$H_N \propto T_N$$

so the thermal energy is directly related to the temperature.

3. Let  $G$  be the gravitational constant (once again, just a constant, not important) and  $M$  is the mass of the gas. Let  $E$  be the gravitational energy of a ring with radius  $R_N$ . Then:

$$E \propto \frac{G \times M}{R_N}$$

So the gravitational energy at any point depends on the mass of the gas and the distance of the point from the center.

4. In Andrew's theory, if you divide the thermal energy by the gravitational energy at the very moment that the gas ring is cast off, then you get some constant, which we'll call  $C$ . So here comes another equation:

$$\frac{H_N}{E} = C$$

If we put the equations from Sections 2 and 3 into this equation (with a small algebraic maneuver) we get:

$$r \times T_N \propto C \times \frac{G \times M}{R_N}$$

And since we're only dealing with proportionalities we can ignore the constants ( $r$ ,  $C$ ,  $G$  and  $M$ ), and write it more simply as:

$$T_N \propto \frac{1}{R_N}$$

So Andrew's theory allows us to recover a well known experimental fact. This is the first test of any theory – it has to be consistent with previous observations.

5. Let  $S$  be the speed of sound. Now the speed of sound in a gas is proportional to “ $R T$  upon  $\mu$ ” as Andrew said:

$$S \propto \frac{R \times T}{\mu}$$

where  $\mu$  is (basically) the mass of the gas particles.

The turbulence of the gas is being driven by the gravity of the cloud, and (copying from above) we said the energy was given by:

$$E \propto \frac{G \times M}{R_N}$$

If we compare the equations for  $S$  and  $E$  then we see that they're not proportional to the same things, so by this reasoning, there is no reason why the turbulence in the gas couldn't be faster than the speed of sound. This is the idea of “supersonic turbulence”, which the whole theory rests on.