**Scrambled Science: Dark Matter**

Why do physicists think that 80% of the matter in our universe is dark matter – a new form of matter - that has never been detected directly?

The following statements are all true. Group the statements by which ones describe the problem and which describe the various solutions. Use these ideas to write an answer in fewer than 50 words.

A: The mass from orbital measurements is 5 times more than from brightness measurements. problem

B: 99% of the mass in our solar system is found in the Sun. planets?

C: The speed of an orbiting star can determine the force acting on it. problem detail

D: Planets are hard to see, but can be found by micro-lensing, wobble, transits planets?

E: The mass of the stars in a galaxy can be found by the galaxy’s type and brightness. problem detail

F: Black holes do not emit light. Blackholes?

G: Black holes can be observed indirectly by micro-lensing and orbits, total mass is too small Blackholes?

H: Our present theory for gravity is well supported by all other observations. Change laws?

I: Neutrinos are very hard but possible to detect (Canada got a Nobel Prize for this) Neutrinos?

J: Astronomers can measure mass by how much it bends light. problem detail

K: Neutrinos have mass and there are lots of them. Neutrinos?

L: Our present theory for gravity is different from 100 years ago. Change laws?

M: If the unseen matter were from neutrinos it would prevent galaxy formation. Neutrinos?

N: The mass of all black holes is not enough (measured by materials ejected during formation) Blackholes?

O: Mass of neutrinos is too small. Neutrinos?

Q: Mass estimates from lensing and orbital motion agree. problem detail

R: Big Bang nucleosynthesis gives the same ordinary mass as the brightness method. problem detail

S: New physical laws could alter the orbital measurement but not lensing. Change laws?

The mass from the brightness method is 20% of that from orbits and lensing. The missing 80% could be planets, black holes or neutrinos but careful searches have ruled these out. Big Bang nucleosynthesis limits ordinary matter to that 20%. Attempts to alter the physical laws weren’t successful.

48 words

Note: Now that astrophysicists have been forced to conclude that the missing matter must be something new they are conducting experiments around the world (including Sudbury) to detect it directly.