Alternative units?

In response to John Powell's Lateral Thoughts article "Hail to the new, popular units" (April p52) in which the author suggests some populist units in light of the EU referendum.

I was fascinated and entertained by Powell's suggestions of some new populist units and his article brought back memories of an incident that occurred some 60 years ago, when I was at school.

We had a physics teacher who was a stickler for always including units when giving an answer to a problem or question. One day, in a practical class, we were asked to find the density of a small piece of a solid material to three significant figures. One of the teams, when asked, gave their result as 189 000.

The teacher said that was a ridiculous answer and they ought to have realized that it couldn't possibly be correct, whereupon the team said "But sir, you haven't asked us what units we are using." "OK, what units are you using?" "Scruples per firkin!"

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Powell's suggestions for populist units are excellent but, sadly, at least half a century late. There is a persistent urban myth that the State of Alabama considered ruling in 1998 that $\pi = 3$ – the Indiana legislature certainly debated the matter in 1897 and other states are rumoured to have proposed $\pi = 22/7$.

Indeed, one Dr J E Goodwin (*The American Mathematical Monthly* 1894) even published a peer-reviewed geometric proof that suggests $\pi > 9$. Turning from constants to units, in the late-1960s Tektronix advertised custom-specified oscilloscopes with the offer of y axis labels in hertz, tesla or whatever, and x-timebases scaled in "millifurlongs per microfortnight, if you wish".

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Powell missed a trick in his search for fluffier, more popular units to replace SI units: he could have added the alliterative firkin as a unit for volume to match fortnight and furlong, which he proposed.

Also, was Keven Hesketh's article "Beyond Hinkley Point" (*Physics World Focus on Nuclear Energy* 2017, pp13–14) inventing a new unit, the horror, as in megawatt-horror: MWhr, instead of MWh?

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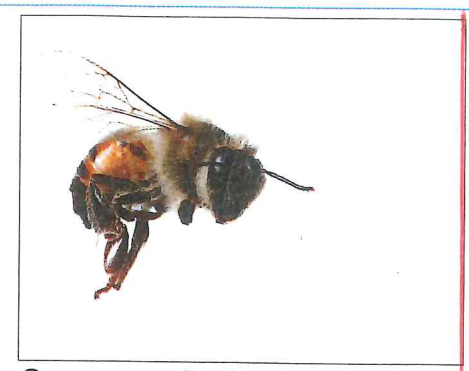

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Open and shut

In response to the Frontiers news story "Honey bees navigate by gut feeling" (May p5), about new findings that bees appear to sense magnetic fields using a magnetic structure in their abdomens.

I read the article on bee navigation and magnetic fields with interest. A couple of years ago, there was a colony of bees, probably no more than a few dozen, under the shed on my allotment, just by the door. If the door was closed, the bees happily entered their hive. But if the door was partly open, even though the entrance to their hive was clearly visible, it completely spooked the bees and they gathered in an angry crowd until I closed it. Does this mean that my shed door is magnetic or is there some other homing mechanism at work? Unfortunately, I cannot repeat the experiment as the Oxford floods submerged the hive and the bees never returned.

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- Listen to our May podcast to hear about the clever ways in which bees exploit electric and magnetic fields, ow.ly/4EPM30bDCSO

Plasma pinch

I am rather worried about whether or not the fusion community understands the behaviour of a plasma. On looking up ITER on the web I found the following sentence: "In a plasma, electrons and ions move independently," but nothing could be further from the truth. In a collision-free plasma the electrons and ions move under the influence of both electric and magnetic fields. These fields are produced by the spatial distribution of charged particles, and by their velocities. It seems to be assumed by the community that the motion of the charged particles depends solely upon the magnetic field, such that they perform helical orbits. But it is very difficult indeed to find a plasma that is free from an electric field. Electric fields are produced by tiny differences between the electron and ion number densities. Such fields in a quasi-neutral plasma were studied by Lewi Tonks and Irving Langmuir in 1929 (*Phys. Rev.* **34** 448); it was Langmuir (*Proc. Natl Acad. Sci.* **14** 627) who introduced the name "plasma" in 1928.

A well-known relation pertaining to the self-magnetic "pinch effect" was obtained by Willard H Bennett (*Phys. Rev.* **45** 890) in 1934. At the 37th European Physical Society Conference on Plasma Physics in 2010 I presented a poster entitled "The Bennett pinch revisited". The theory used by Bennett was entirely different from that found in the textbooks on plasma physics, which use a theory based on "magnetohydrodynamics" – the theory of electrically conducting liquids. Bennett considered instead two assemblies of particles, one of electrons and one of positive ions. A relativistic treatment was employed, although the "non-relativistic" results could be readily deduced and was given by Bennett. The conclusion reached on reading this paper is that, in the well-known "pinch effect", the positive ions are contained by a radial electrostatic field (ignoring instabilities for the present discussion). The $(\mathbf{j} \times \mathbf{B})$ force is transmitted to the ions via the electrostatic field. It follows that the generally accepted view that "magnetic confinement" can be explained by simply considering the ion orbits in a magnetic field of a suitable configuration is incorrect.

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Sage advice

I have just read Peter Medawar's excellent book *Advice to a Young Scientist*. I had read it once before as a young man, but returning to it aged 55 I appreciated it so much more. Embarking on physics PhD studies in 1986, I had a very unwise attitude. The same could be said of my supervisor. I developed into somebody who valued pure over applied science. I had no idea about my limitations and was way too ambitious. As a result I never got my PhD and effectively blighted my whole career. If only I had received a short course along the lines of Medawar's book as an undergraduate I feel that some of my mistaken attitudes might have been corrected before they did serious damage. Perhaps this is something our present-day science educators could take into account.

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