Fine grain physics

In 1895, a German engineer published a short paper reporting the results of experiments on corn silos. This was the same year that Hendrik Lorentz published an approximate form for the coordinate transformation appropriate for Maxwell's equations, and one year after George FitzGerald had suggested 'length contraction' as a possible explanation for the original null result of Michelson and Morley, reported in 1881, for the speed of the Earth's movement through the aether. Intellectually speaking, H. A. Janssen's experiments were miles away from these precursory ideas of the theory of relativity, yet they prove that scientific truism — remarkable science often lurks in the most ordinary of circumstances.

At the time, a huge industry had grown up to move corn from producing nations to locations all around the world. Silos acted as storage facilities along the way, taking deposits from the railways and dispensing to ships. Janssen noticed that construction books offered little guidance about the required strength of a silo's walls, based on estimates of how much pressure a tall column of corn might exert against them. What's more, it was apparently common knowledge at the time that the pressure in a corn silo works very differently from that in, say, a column of water.

The pressure at the base of a fluid column, of course, simply grows with the column's height. But as corn pours into a silo, the pressure at the base ultimately reaches a limit, and pouring in more corn, strangely enough, has no effect. Janssen's experiments, using small-scale wooden silos that he constructed himself, confirmed that the pressure reached a limit in this way. Making several simple assumptions, he also managed to calculate the pressure profile in close agreement with the data.

Thanks to Matthias Sperl, scientists who do not read German now have access to an English translation of Janssen's original paper (http://arxiv.org/abs/cond-mat/0511618). As he recognized, the distinctive behaviour of what we now call 'granular matter' has to do with friction. Acting between pieces of corn, friction effectively locks the silo's contents into a semi-rigid whole, and friction at the walls can then help to support the column's weight. It's very different from a column of water or other fluid, which cannot support shearing forces.

REMARKABLE SCIENCE OFTEN LURKS IN THE MOST ORDINARY OF CIRCUMSTANCES.

What is most striking, however, is Janssen's awareness of deep differences between ordinary matter and granular matter, as exemplified by the corn in his silos. Janssen tried without success to devise experiments that would probe the pressure at specific points on the silo walls. He attributed his difficulties to the 'arching' of force within the corn; that is, to the transmission of force from grain to grain along irregular branching paths, which leads (we now know) to far higher stress in some locations than in others. Ultimately, such effects stem from thorny issues that confront modern physics in many settings — namely, disorder and the absence of equilibrium. Indeed, it now appears that granular systems in many circumstances exhibit striking similarities to glassy materials.

Janssen's experiments and explanations of them greatly improved silo design in subsequent years. But as far as physics is concerned, he was a pioneer. As Sperl notes, Janssen's paper had been cited 40 times before 1977 — on average less than once a year. Since then, it has been cited 375 times, and more than 150 times in the last decade alone.

Mark Buchanan

Physics and philanthropy

Particle physics is big science. That is its allure, and its challenge. The fundamental constraints imposed by quantum mechanics mean that probing ever-smaller scales requires ever-higher energies. Although some may be concerned about the esoteric realms that physicists seek to explore, we need to do so to shed light on such questions as the origin of mass, and even of the Universe itself. We may not be successful, but there is nothing to suggest that the effort will be fruitless.

Nevertheless, it has always been a challenge to convince governments that they should spend huge amounts of money on particle accelerators. And in tough financial times, cutting the funding for such projects is politically safe. The scientific community (or at least part of it) may protest, but this often looks to congress and the public like self-interested lobbying.

In the US Department of Energy 2006 Budget, the funding allocated to Brookhaven National Laboratory's Relativistic Heavy Ion Collider was enough to operate it for only 12 weeks. Things got worse for RHIC — which collides beams of gold ions head-on, to explore the nature of the strong interaction in a regime where new quark-related phase transitions should occur — when unexpected increases in energy costs meant that the allotted funds were insufficient for even this limited run.

But then a group of private individuals led by Jim Simons — known for the Chern–Simons topological invariant in theoretical physics, but, more importantly, the billionaire president of one of the most successful hedge funds in history — donated US$13 million to enable RHIC to run for a full 20 weeks this year.

A WELCOME RESPITE FOR BROOKHAVEN, BUT WHAT ARE THE LONG-TERM IMPLICATIONS?

It's a welcome respite for Brookhaven, but what are the long-term implications? Will governments now assume that large accelerator laboratories can glean support from the private sector, providing an excuse to lower government funding? Perhaps this will bring forefront science back to its philanthropic origins — when wealthy patrons were the primary supporters of research. If so, particle physicists will have cause to root for a bull market.

Lawrence M. Krauss