SPIN WAVES

Law and order

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In magnetic materials, a disturbance in the local spin ordering can propagate as a wave. Such spin waves carry information and as they do not suffer from the heating effects associated with moving charges they are touted as potential data carriers for next-generation computing devices. But for this to happen, the propagation of spin waves needs to be predictable and controllable. Johannes Stigloher and co-workers have now shown that a rule analogous to Snell's Law in optics can explain how spin waves travel between two media.

Snell's Law describes how light waves refract at the interface between different media. By exciting spin waves in a thick permalloy film and watching how they propagate into a film with a lower thickness, which has a different dispersion relation, Stigloher *et al.* probed the refractive behaviour of spin waves. For low incidence angles, they showed that the refraction and reflection of spin waves in the dipolar regime could be described by a law similar to Snell's. And although deviations are found at large incidence angles, this provides a clear route for both predicting and controlling the propagation of spin waves. *LF*

COLLIDER PHYSICS

The next generation

Europhys. J. A (in the press); preprint at http://arxiv.org/abs/1212.1701

Gluons are to the strong interaction what photons are to the electromagnetic force. But unlike chargeless photons, gluons carry colour charge and can interact with each other. Little is known about what happens when the density of gluons is high, although one would expect saturation at some point. The distribution of quarks and gluons inside a nucleon is also an open question — as are the exact roles of the nucleon properties and the nuclear environment. To answer these questions we need to access the gluon-dominated regime, which has so far only been glimpsed in experiment.

Almost a decade ago, the Brookhaven National Laboratory and the Thomas Jefferson National Accelerator Facility commissioned a study to assess the potential of exploring this frontier with an electron–ion collider. The result of a community-wide effort, the proposal lays out an updated design for the collider using hundred GeV ions from the already functional Relativistic Heavy Ion Collider. The electrons would be accelerated to some 20 GeV by an energy recovery linac; this reuse of existing facilities would provide a cost-effective way to build this unique machine. *IG*

FUNDAMENTAL CONSTANTS

Planck precision

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Scientists' most authoritative reference — the International System of Units (SI) — is undergoing fundamental changes. In the new SI all seven base units will be defined via the values of seven defining constants. The redefinition of the kilogram, for example, relates to the value of Planck's constant h. So before the new definition of the unit of mass can be put into practice, h must be precisely determined.

Darine Haddad and colleagues have developed a new instrument for precise measurement of h. The apparatus is a state-of-the-art Watt balance, which compares a mechanical force (or weight) with an electromagnetic force generated by a moving conducting coil in a magnetic field. A temperature-stabilized underground room shielded from radio-frequency waves houses the instrument, sitting within a vacuum chamber on a concrete block.

After extensive alignment work, required to obtain the precise values of all of the quantities involved, data was collected over a few weeks. Proper analysis, taking uncertainty budgets into account, then led to a value of $h = 6.62606983(22) \times 10^{-34}$ J s. The authors plan to realize an even more precise value in a year's time. *BV*

BIOPHYSICS

Blurred vision

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That the octopus succeeds in camouflaging itself is something of a puzzle. And here's why: like most cephalopods, they have a single unfiltered photoreceptor type — they're colour blind in the traditional sense. But Alexander and Christopher Stubbs think they might have hit on the mechanism by which these organisms discriminate between colours. And it comes down to having a funny-shaped pupil.

Equipped with a lens that has a wavelength-dependent index of refraction, the octopus experiences chromatic blur, in which different wavelengths come into focus at different distances from the lens. The mechanism that Stubbs and Stubbs put forward, and study numerically, suggests that the spectral content of the organism's environment could be inferred from monitoring the variation in blurriness as the lens-to-retina distance is altered. The off-axis geometry of the pupil maximizes the chromatic blurring, but does so at the expense of acuity — implying it may have evolved to facilitate this special type of spectral discrimination. *AK*

HISTORY OF SCIENCE

Maxwell pass, Heisenberg fail

Stud. Hist. Phil. Sci. **58,** 24–33 (2016)

A well-chosen *Gedankenexperiment* can, famously, open up entirely new avenues of study. But when does a thought experiment really contribute to our scientific understanding of the world? Michael Stuart suggests that two kinds of tests may help in answering that question.

The tests are not new, but are routinely applied to find out if students have understood a new idea presented to them. Tests of 'meaningfulness' determine whether someone has created the right connections between a theory, model or concept and the rest of their knowledge. Tests of 'fruitfulness' check whether a student can apply an idea to "achieve something that we could not have achieved before".

Stuart has found that several classic thought experiments — Maxwell's demon among them — pass these tests, but others fail. In the latter category is Heisenberg's microscope, designed to provide an intuition of the trade-off between position and momentum. It does so, however, in a rather misleading manner, preventing us from making fruitful new connections. These examples from the past underline that the proposed tests should serve as a handy calibration for those thinking up new thought experiments. *AHT*

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