Catch the drift

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It's infuriating, isn't it? Your instrument is well calibrated, the systematic errors understood and a good averaging strategy is in place to reduce the noise — but then the temperature drifts away, and with it the signal. In so many experiments, instrumental drifts owing to slow variations in experimental conditions limit the attainable measurement precision. But Valeriy Yashchuk proposes a general approach that should help to effectively suppress such errors.

The basic idea is to beat the drift by repeatedly reversing either the direction along which the signal is scanned or, if possible, the sign of the recorded quantity. In either case, the sequence of reversals is arranged such that it anti-correlates with the temporal dependence of the drift, with the result that its effect is averaged out.

The trick is of course to find the right sequence for the reversals. Yashchuk describes an analytical expression for optimal measurement strategies to suppress drift errors of a given polynomial order, together with a recursion rule for finding the optimal scanning sequence in a given experiment.

Nano-Raman rendezvous

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Raman spectroscopy is a powerful technique for determining the chemical composition and structure of an object. Unfortunately the scattering processes on which it is based are weak. This usually means you either need a large sample volume or an intense laser probe to generate a useful Raman signal.

But it has also been found that when a sharp metal tip is irradiated with a laser, the excitation of surface plasmon polaritons can significantly enhance the optical field around the tip and, in turn, the Raman signal from any surface placed near the tip. By scanning the tip across a surface, a map of its chemical composition can be constructed.

De Angelis and colleagues extend this idea to close to its fundamental resolution limit. Rather than excite surface plasmon polaritons in a tip directly, they launch them into the tip by mounting it at the centre of a laser-excited photonic-crystal cavity. This significantly lowers the background laser field, increasing the contrast at the tip, and achieving a spatial resolution of 7 nm. Moreover, by fabricating the tip structure on an atomic force microscope cantilever they can map the chemistry and topology of the surface simultaneously.

Tried and true

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The lofty goal of quantum gravity is to unify two very successful theories, quantum mechanics and general relativity, which are self-avoiding: quantum mechanics ignores gravity and general relativity ignores quantum effects. But at small length scales, for instance the Planck scale of $\sim 10^{-35}$ m (or energy $E_{\mathrm{Planck}} \sim 10^{19}$ GeV), the effects of gravity could affect the properties of spacetime. In fact, a valid question is whether Lorentz invariance holds in such conditions.

For decades, the energy scales involved have precluded stringent laboratory tests, leading some to question the scientific basis of such 'theories of everything'. But, as luck would have it, high-energy γ-ray bursts from cosmological distances can test the validity of Lorentz invariance at the Planck scale.

By analysing the features of the short γ-ray burst of 10 May 2009, including a 31 GeV photon, Aous Abdo *et al.* have found no evidence for Lorentz-invariance violation. Certain theories assume that quantum fluctuations cause propagating particles to behave differently, according to their energy. Up to $1.2E_{\mathrm{Planck}}$, the authors are confident that there is no linear variation of light speed with photon energy.

Cosmic slow-down?

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The rate of expansion of the Universe, as seen through the observation of supernovae, has been accelerating; dark energy is postulated as an explanation. But Arman Shafieloo and colleagues wonder whether the acceleration might actually now be slowing down.

The dark-energy equation of state — the ratio of its pressure to its energy density — is usually assumed to be constant. Shafieloo *et al.*, however, chose to analyse the growing sample of relevant data on the recent history of the Universe making no such assumption. Using the 'constitution set' of hundreds of type 1a supernovae between redshifts of 0.015 and 1.551, baryon acoustic oscillations and data on the cosmic microwave background radiation, the authors find cause to revise an ansatz within the standard analysis, and conclude that the supernovae data in particular suggest some evolution of dark energy at low redshifts.

There could be a mundane explanation, such as misunderstood systematics in the datasets, but Shafieloo *et al.* urge the collection of more data — and an openness to such "subtle challenges" to the prevailing model.

The predictable choice

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The erratic nature of mankind might make individual actions difficult to predict, but choice when averaged over a large group of individuals is often found to obey stochastic rules. This idea has now been applied to the decisions made during the first few moves in chess.

Chess makes an interesting case study in decision making because it allows the player to choose from a large, but finite, set of possible moves. It has been estimated that there are approximately 10^{120} different game sequences, and yet experienced players tend to choose from only a handful of opening moves.

Zipf's law states that the frequency of any action is inversely proportional to its rank in the frequency table. Bernd Blasius and his colleagues have analysed extensive chess databases and found, accordingly, that the frequencies of chess openings are distributed according to a power law with an exponent that increases linearly with the game depth.

Although this research may not turn us all into grandmasters, understanding group decision making has important implications in, for example, predicting stock-market movements.

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