

between the two cases. In contrast to average current measurements, shot noise probes current fluctuations, which can yield valuable information on the microscopic mechanisms involved in the charge transport. When transport is dominated by weak backscattering events, the shot noise is simply determined by the product of the average backscattered current and the effective charge, e^* , of the relevant backscattered particles. This has previously allowed measurements of the fractional charge $e^* = e/3$ — here e is the fundamental electron charge — of quasiparticles in the fractional quantum Hall state at filling factor $1/3$.

Although it contains rich information on the transport characteristics of a system, experimental and theoretical investigations of shot noise are challenging. Experimentally, this is because low-frequency current noise is often dominated by extrinsic $1/f$ noise. Few experimental studies on Kondo dots are available so far, one recent example⁷ being the experimental evidence for reduced shot noise with $e^* = 5e/3$, the universal effective charge expected at very low temperatures for the SU(2) case. In turn, theoretical treatments of shot noise necessarily have to be conducted in non-equilibrium settings, which is the reason that they are more difficult to perform

than linear conductance calculations. In fact, just a few reliable theoretical methods — each covering only restricted parameter regimes — are available at present. For the SU(4) Kondo dot, Fermi liquid theory^{8,9} predicts enhanced shot noise with universal charge $e^* = 0.3e$. Shot noise therefore offers a 'smoking gun' to distinguish between different types of Kondo effect.

Although the experiments reported by Delattre *et al.* have not yet reached the ultimate low-energy limit described by Fermi liquid theory, they represent an important advance in condensed matter physics. Their work is the first to report a clear and significant shot noise enhancement compared with the non-interacting case. This is a distinct signature of the SU(4) Kondo effect, distinguishing it from the SU(2) case, for which a shot noise reduction is expected instead. In fact, Delattre *et al.* show that their results are well described by a temperature-dependent self-consistent mean-field approach, but only when SU(4) is taken as the relevant symmetry group. This breakthrough establishes shot noise as a leading approach in identifying subtle many-body effects, as was the case a decade ago for fractional quantum Hall systems.

These results point to a wide class of exotic Kondo problems that are now

coming into experimental reach. A combination of spin and orbital degrees of freedom, possibly with additional degenerate lead channels, gives rise to a plethora of interesting new many-body problems. Such situations can be realised in nanodevices even out of equilibrium and are also likely to yield non-Fermi liquid behaviour. More progress on the Kondo story can be expected in the near future, and the work by Delattre and colleagues³ is an important step in the right direction. □

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DARK MATTER

Many birds, one stone

A new theory for dark matter has the power to explain several experimental results simultaneously, even those seemingly at odds with each other.

Dan Hooper

An increasingly compelling body of evidence, accumulated over the past months and years, signals that the Milky Way contains a surprising number of highly energetic electrons and positrons. In particular, the satellite-based experiment PAMELA has measured¹ the positron fraction — the ratio of the number of positrons to the number of electrons plus positrons — in the cosmic-ray spectrum to be climbing rapidly above energies of 10 GeV. The balloon-based ATIC has also observed² an intriguing feature in the cosmic-ray electron (plus positron) spectrum, between about 300 and 800 GeV. Together, these observations seem to imply the presence of a relatively nearby source (or sources) of electrons and positrons

at gigaelectronvolt to teraelectronvolt energies. Furthermore, the observation by WMAP^{3,4} of anomalous emission from the inner region of our Galaxy suggests that energetic electrons and/or positrons are highly abundant there as well.

Although the origin of these particles remains unknown, an exciting possibility is that they may be the product of the annihilation of dark-matter particles in the halo of the Milky Way. But efforts to explain these signals using dark matter face a number of challenges. First, the spectrum of electrons and positrons generated by dark matter is generally too soft unless the annihilations proceed mostly to leptons (the particle family that includes electrons and positrons, and muons and taus) rather

than to quarks, gauge bosons and so on. On a similar note, many dark-matter candidates are predicted to produce more cosmic-ray antiprotons than are observed if the annihilation rate is normalized to the electron and positron signals registered by PAMELA and ATIC. Once again, this seems to favour annihilations that proceed largely to electrons, muons or taus. Finally, to produce these signals, the dark matter must annihilate at a rate hundreds or thousands of times higher than would be naively predicted for a thermal relic.

Writing in *Physical Review D*, Nima Arkani-Hamed and colleagues propose⁵ a model for dark matter that solves each of these problems, and a couple of others to boot. The basic idea is this: in