most likely to trigger new investigations in other contexts, as these principles are so common in human decision processes. We can therefore look forward to diverse applications of the model of Song *et al.*[1]. For example, one may wonder if the same basic mechanisms determine what restaurants we visit, what recipes we try if we decide to dine at home or what locations we pick for a summer holiday. Once data for these contexts are available we should expect to see similar patterns emerging. ❐

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QUANTUM CRITICALITY

Noise gets marginal

Thermal noise destroys the fragile correlations that characterize many-body systems at a quantum critical point. Theoretical work now shows that another generic form of noise acts differently: flicker noise may alter some properties of a quantum phase transition, but it can preserve the quantum critical state.

Sebastian Diehl

The quantum mechanical properties of a many-body system are most clearly revealed at zero temperature, where it is in its ground state. An interesting situation occurs when there are two competing microscopic mechanisms, each of which favours a different kind of ordering pattern, such as paramagnetic versus antiferromagnetic arrangements in a spin array. Tuning the ratio of the corresponding energy scales (by applying, for example, pressure or external fields) transforms the macroscopically distinct phases into each other through a quantum phase transition[1]. In many cases, the two phases of matter are continuously connected. The corresponding quantum critical point is then characterized by long-range correlations in both the spatial and temporal domain. One aspect that makes such points interesting is their high degree of universality — the low-energy correlations are insensitive with respect to details of the underlying microscopic model.

Despite this robustness regarding microphysics, the system at the quantum critical point is a highly fragile state of matter. In particular, finite temperature is an adversary to quantum criticality. Strictly speaking, an infinitesimal temperature immediately destroys the subtle correlations (see Fig. 1a). Writing in *Nature Physics*, Emanuele Dalla Torre and colleagues[2] argue that there are forms of noise that do not destroy quantum critical correlations. These varieties of noise are by no means exotic: conventional flicker noise — also known as $1/f$ noise and ubiquitous in (classical) electronic devices — is shown to preserve quantum criticality.

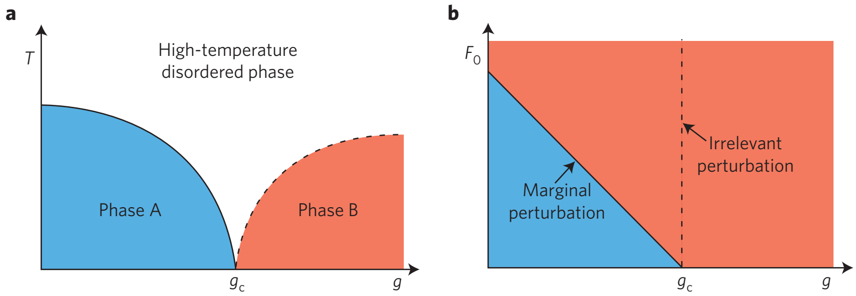

Figure 1 | Impact of thermal (equilibrium) and flicker $1/f$ (non-equilibrium) noise on a quantum critical point at the critical interaction strength g_c. **a**, A finite temperature T acts as a relevant perturbation, destroying quantum criticality: the critical point separates two distinct low-temperature phases A and B, whereas a finite temperature immediately destroys the characteristics of either phase. **b**, $1/f$ noise acts as a marginal perturbation. The distinct phases at $F_0 = 0$ remain intact at finite noise strengths F_0, but the location of the phase boundary is shifted. For an irrelevant perturbation, such shifts would be much less pronounced.

Temperature may be conceived as external thermal white noise that acts on a system due to the coupling to a heat bath in thermodynamic equilibrium. Dalla Torre *et al.*[2], in contrast, look at quantum criticality from a more general perspective, beyond the realm of thermodynamic equilibrium. They find forms of non-equilibrium noise that leave the quantum critical correlations intact, giving rise to a new scenario: non-equilibrium quantum criticality. They establish their key result in a renormalization-group framework. In this language, a (quantum) critical point corresponds to a fixed point under coarse-graining renormalization-group transformations of the system's parameters. Perturbations around a fixed point can be classified according to their degree of 'relevance'. In a quantum critical system such as the one considered in Fig. 1a, there is a single relevant perturbation that may be fine tuned to the fixed point. Other departures from the fixed point are usually 'irrelevant' (this explains the insensitivity to microscopic details). A finite temperature, however, acts as an additional relevant perturbation, thus driving the system away from criticality[1]. Flicker noise falls into another class of perturbations, termed 'marginal': in this case, the universal quantum critical correlations are preserved. However, unlike irrelevant perturbations, additional marginal perturbations have directly observable consequences: They affect the non-universal properties of the transition, such as the precise location of the phase boundary as a function of the microscopic parameters (Fig. 1b).

In which quantum systems then could this scenario be actually observed? A natural requirement is a situation in which cooling and $1/f$ noise balance each other in a way that allows a non-equilibrium steady state to exist. To underpin the basic picture described above, Dalla Torre *et al.*[2] elaborate on the case of a resistively shunted noisy Josephson junction. Starting from there, they identify true one-dimensional many-body systems that may exhibit non-equilibrium quantum criticality. They propose studying the effect using either ultracold polar molecules, which have recently become available in the laboratory[3,4], or trapped ions, which can be controlled with exquisite precision[5]. Chains of molecules or ions may be suitably cooled, while being at the same time subject to fluctuating electric fields as a natural source of $1/f$ noise. Experimental observation of the fragile quantum critical correlations in these one-dimensional systems will, undoubtedly, be demanding. The challenges will come, for instance, with the required fine tuning of cooling against noise-drive parameters.

One distinguishing aspect of the scenario considered by Dalla Torre and colleagues[2] is its intrinsic non-equilibrium character. In fact, there are 'smoking gun' signatures for the departure from thermodynamic equilibrium. Possibly the most striking among them is an oscillatory behaviour between energy loss and gain with increasing $1/f$-noise strength. This implies that the noise may have the effect of a 'pump' to the system, in some analogy to laser driving.

The perhaps counterintuitive fact that noise and dissipation do not necessarily act as an adversary to subtle many-body quantum correlations has been recognized recently in different contexts both theoretically[6–8] and experimentally[9,10], where dissipation is tailored in a way to enforce specific steady states with quantum mechanical properties such as phase coherence in ensembles of bosonic atoms[6], or entanglement in spin systems[7–10]. The work by Dalla Torre and colleagues adds an intriguing new class of systems to the fledging field of many-body quantum physics beyond thermal equilibrium. ❐

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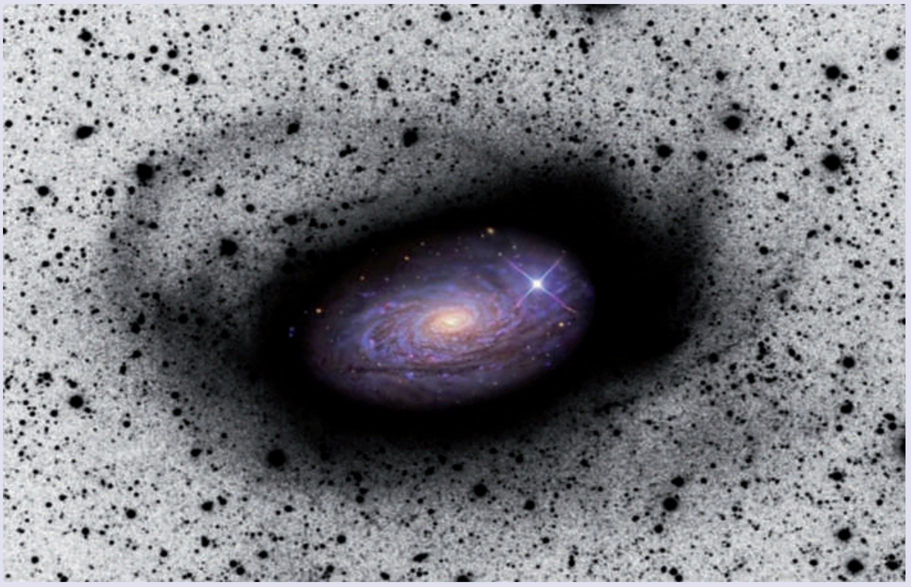
ASTRONOMY

Galactic left-overs

This is Messier 63, also known as the sunflower galaxy. First observed in 1779, by the mid 1800s its spiral structure had been resolved, making it one of the first spiral galaxies identified. This image — positive at the centre, negative around the edges, and published by David Martínez-Delgado and colleagues in the *Astronomical Journal* (doi:10.1088/0004-6256/140/4/962; 2010) — shows fresh detail in the galaxy's outermost regions, revealing wispy tendrils that are all that remain of another satellite galaxy, swallowed up by M63.



R. JAY GABANY / D. MARTÍNEZ-DELGADO *ET AL.*

Similar evidence of galactic guzzling had been seen for the three spiral galaxies that are members of the 'local group' of nearby galaxies (which includes the Milky Way). But Martínez-Delgado *et al.* have probed deeper into space, building a wider sample of galaxies that are up to 50 million light years away.

Their data support current thinking on galaxy evolution, particularly on the likely chain of events when a dwarf galaxy has the misfortune to get too close to a spiral giant: typically, the uneven gravitational pull of the larger galaxy disrupts the smaller one, dragging its stars into a tidal stream that will eventually — over billions of years — be completely assimilated.

The team collected the data using small-aperture, robotic telescopes at privately run observatories in the USA and Australia, and are already extending their survey to enable more quantitative tests of galaxy-evolution models.

ALISON WRIGHT