of the quantum system is encoded in the solutions of the corresponding Einstein equations. Insights from general relativity and cosmology can therefore help unravel difficult quantum problems. This duality also enables a correspondence or 'dictionary' between the quantum and gravitational observables. For example, the temperature of the quantum system corresponds to the Hawking temperature of a black hole. A key feature of the holographic approach is that it is formulated in real time, and does not involve the usual analytical continuation to the imaginary axis. This makes it very useful for studying dynamical response functions, such as the a.c. conductivity. Indeed, the damped eigenmodes of the black holes[8], or quasi-normal modes, have a direct impact on the frequency dependence of the conductivity. The quasi-normal modes thereby act as proxy for the non-existent quasiparticles.

In the past few years there have been a growing number of connections between gauge–gravity duality and condensed matter physics; for reviews, see refs 9–11. In addition, there have been exciting advances, including holographic duals of superfluids and strange metals. The overriding question is whether these holographic techniques can be exploited to describe real physical systems in the condensed matter laboratory, or if they are restricted in their scope. The paper of Witczak-Krempa *et al.* is a serious attack on this central problem. They claim that holographic duality can be used to extract the universal properties at realisable quantum critical points.

This innovative paper provides many fresh insights, and also raises interesting questions for future research. For example, in order to compare the quantum Monte Carlo data with the holographic model, the team observe that they need to rescale the frequency axis. Is this a signal of new physics? Can this holographic continuation procedure be applied to other models in different universality classes?

In my view, the most compelling aspect of this bold and adventurous work is that the predictions of numerical simulations and AdS/CFT can potentially be tested in experiment. Ultimately, this will be the most important step in getting back to reality. ❐

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SPORTS SCIENCE

In pursuit of power

Many sports require athletes to generate considerable physical power. This is perhaps best embodied by time-trial cyclists (pictured), who are tasked with pedalling a given distance in the shortest possible time. On an indoor velodrome track, this feat is reduced to its bare essence, eliminating factors like wind, rain or hills.

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Lindsey Underwood and Mark Jermy have now designed a mathematical model that helps to establish the optimal pacing strategy for cyclists competing in the individual pursuit track events: 4,000 m and 3,000 m for men and women, respectively (*Sports Eng.* http://doi.org/r9q; 2014). Strictly speaking, the individual pursuit is not truly individual, as the formal goal in the knock-out stage of a competition is to 'catch' the other rider, who starts half a track length ahead. Most often, however, success comes down to clocking a faster time than the competition.

Rather than starting with a spherical bike-and-rider approximation, Underwood and Jermy collected data on the performance of 11 male and female athletes during actual rides. They used the cyclists' produced-power profiles to quantify the 'potential' of riders through peak, average and integrated power, the latter being the total work delivered. Power profiles were readily accessible using a monitoring device that was coupled to the crank of the bike.

The authors were then left with a well-defined mathematical problem: for given maximum and integrated power production, what is the optimal power as a function of time to establish the fastest race time? The relevant equations involve the forces exerted on the bicycle and the balancing of power supply and demand, with excess power going into acceleration. The model features parameters related to ambient conditions (temperature, pressure and humidity), the athlete (weight and height), the bike (frame mass, wheel radius, saddle height and gear ratio) and the track (banking angles and curvature radii).

The authors tested many scenarios and found that the best pacing strategy started with an all-out acceleration lasting 12 to 16 seconds, followed by a period of slightly lower constant or fluctuating power, with a difference of 100 W between bends and straights. A better understanding of an athlete's ability to regulate anaerobic activity — required for the all-out acceleration, but desirable throughout the lower-power phase too — could result in even more sophisticated models.

The current world records stand at 4 min 10.534 s for the men's 4,000 m, and 3 min 22.269 s for the women's 3,000 m. Challengers aspiring to pinch off a few milliseconds now know how to optimally distribute their power.

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