or collectively, through a quantum-mechanical property known as entanglement[10,11].

But theories of superconductivity rely on the idea that pairs of electrons can be described as composite particles that act like bosons with integer spin. And materials with superconducting (and hence bosonic) character show a peculiar response to applied magnetic fields when disorder is introduced with a microscopic pattern of holes[12]. The quantum nature of the bosons on the islands requires that an integer number of magnetic-flux lines threads through the holes — each carrying a quantum of magnetic flux (Fig. 1). When the applied magnetic field lies between these integer values, the material's electrical resistance increases. The result is a bosonic calling card: oscillations of resistance with changing magnetic field strength. And Yang and co-workers' sample showed precisely this response below the critical temperature for superconductivity — offering direct evidence that a strange metal exhibits electronic transport with bosonic character.

The leading theoretical descriptions of strange metals are as varied as the materials that show strange-metallic behaviour — some even draw on surprising connections to black-hole physics[13,14] — but a consensus model has yet to emerge. Possible connections to an underlying anomalous metallic phase are even more speculative. As the temperature approaches zero, the electrical resistance of many disordered 2D superconductors reaches a constant, non-zero value — but this behaviour is impossible according to theories that describe non-interacting electrons. Sometimes termed a bose metal, this anomalous state is similarly in need of a consensus microscopic theory, despite more than two decades of theoretical and experimental attempts to devise one[15]. Conclusive evidence that an anomalous metal lies at the zero-temperature limit of a strange metal would be a major result.

The present study leaves several questions open. First, on a technical level, it seems that control of the patterning process was key to Yang and colleagues' findings. An earlier paper by members of the same group reported a similar system[16], but strange-metallic behaviour was observed in the present study only when the patterning was made more uniform than that of the previous study[2]. Quantitative investigation of the interactions between nodes could address this issue.

Second, assuming that strange-metallic behaviour can lurk in sufficiently disordered superconductors, why hasn't it been routinely observed in the panoply of materials and systems studied so far? An experiment reported last year counters this concern: nanopatterned films of the superconductor iron selenide also show electrical resistance with a linear dependence on temperature, suggesting another instance of strange-metallic behaviour in a system characterized by bosons[17].

These findings are as fascinating as they might be challenging to reconcile. The work of Yang *et al.* represents an intriguing opportunity to unite two frontiers — strange metals and disordered superconductors — whose collective description would represent a major step forward for condensed-matter physics.

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Archaeology

Beads reveal long-distance connections in early Africa

Benjamin R. Collins & Amy Hatton

Beads made from ostrich eggshells, produced by people over the past 50,000 years, provide evidence for a long period of social connection between eastern and southern Africa, followed by isolation and then reconnection. **See p.234**

"Let's keep in touch!" is a phrase commonly used to indicate a social bond formed between people. Ideally, such bonds are maintained even across long distances and over the passage of time. Today, keeping in touch is easy, whether through a call, a text message, social media or the now omnipresent virtual meeting. However, what traces might remain of signs of social relationships from 50,000 years ago, and why is investigating these ancient relationships useful? Miller and Wang[1] present data on page 234 suggesting that small beads made of ostrich eggshell (OES) and fashioned into jewellery were exchanged between groups across eastern and southern Africa as part of long-distance social connections over the past 50,000 years. These relationships, across immense distances, then broke down about 33,000 years ago — around the same time as major climate changes occurred — and were renewed only about 2,000 years ago, the authors suggest.

Ostrich-eggshell beads were (and still are) commonly used to make jewellery, such as headbands and necklaces, as well as to decorate clothing and bags[2]. Studies indicate that the exchange of OES beadwork is a key way to forge social ties between different groups of foragers, both in modern and in historical times. These ties between communities might have provided social safety nets for groups falling on hard times and contributed to interactions that led to the spread of genes and ideas[3,4]. Similar practices of bead exchange are cautiously considered when studying the deeper past. OES beads — and the jewellery they were used for — are thought to be items that would probably have been exchanged between socially connected groups, and therefore indirectly suggest the presence of past social networks.

Archaeologists study bead characteristics, such as bead diameter and geochemistry, as a way to trace bead movements across past landscapes and to explore past social connections[5–7]. Miller and Wang emphasize the need to consider the features of individual beads because each step in the manufacturing process reflects deliberate choices that can be influenced by social and cultural norms. These norms, or styles, are typically shared between socially connected groups and diverge when groups have weaker social links, or none at all. Differences in bead diameter can therefore be considered stylistic choices and can inform our understanding of past social connections, because groups that are socially connected can be assumed to produce beads with similar

Figure 1 | Use of ostrich-eggshell beads to track social connections. Miller and Wang[1] analysed climate and bead data from sites in eastern and southern Africa. The authors tracked the diameters of beads over the past 50,000 years, and propose that beads of similar diameters found at different sites could indicate evidence of bead exchange during social connections. The bead data indicate a long period of connection between the two regions, followed by a long period of isolation before reconnection. Climate data suggest that the time of isolation coincided with periods of flooding of the Zambezi River, which might have created a barrier to movement between the regions.

diameters. This approach is extremely useful for archaeologists because, typically, only individual beads are recovered from what was once a necklace of beads.

Archaeological evidence suggests that OES beads were first made in eastern Africa, because this is where the oldest known beads of this type have been found. Miller and Wang argue that this technology then spread to southern Africa and that the phenomenon reflects a period of social connection between these regions from 50,000 to 33,000 years ago. This connection is demonstrated by bead diameters that remained very similar between sites from eastern and southern Africa, and suggest social connections across the longest distances so far recorded in Africa for this early period. Interestingly, this period of connection occurred when eastern Africa was experiencing conditions that were wetter and that had more rainfall than the next period of study of this region.

From 33,000 years ago, bead-diameter sizes were notably different between eastern and southern Africa, a difference that continued until about 2,000 years ago. This divergence is argued by the authors to represent a breakdown in social connections between the two regions.

Miller and Wang note that this proposed separation occurred at a time when the climatic conditions became much drier in eastern Africa than before, but when southern Africa started to receive more rainfall than it had previously done. Population sizes are thought to have been low at this time. Climate data suggest that the longest east-flowing river in Africa — the Zambezi (Fig. 1) — probably expanded and flooded the landscape multiple times during this period[8], and might have created a barrier between eastern and southern Africa. Traversing this landscape barrier, or others, might have been too challenging during this period, contributing to a breakdown in social connections. Bead sizes between the regions became consistent again about 2,000 years ago, indicating a period of social connection that was associated with the movement of early herders from eastern to southern Africa[5].

Miller and Wang provide a large data set of OES beads that makes a strong case for their arguments. However, their study focuses only on stylistic trends in OES beads, and it could be complemented by research that identifies the initial source, or provenance, of the OESs used to make the beads. Provenance studies are able to identify the region in which an ostrich egg was laid, and this information can be used to track the movement of OES beads across landscapes by studying their geochemistry. Such studies have been successful in southern Africa[7,9], but have not yet been reported on a continental scale.

Studies of other types of common artefact from this period would further test these arguments. Stone tools are the most commonly recovered artefacts from archaeological sites, and also have styles that could reflect social and cultural norms. In this respect, a comparison of stone-tool styles that mirrors the analysis of the OES beads would provide further insight into the proposed periods of population connection and isolation across Africa.

Miller and Wang's study is crucial for cementing the value of OES beads for understanding the social interactions of people in the past. However, for the beads to continue to provide insights, they need to be analysed in a consistent way, something that the authors and others have emphasized[6,10]. Miller and Wang also highlight the necessity for studies that incorporate multiple lines of evidence to understand the past, such as assessments of ancient DNA, consideration of the range of artefacts present and the evaluation of past environments. Such approaches are crucial for understanding the complex nature of early social interactions, and the movements of peoples, ideas and technologies across space and over time.

Ostrich-eggshell beads have often been overlooked in the archaeological record. These tiny beads can tell us so much, and African researchers are best placed to trace their importance over time, from the present to both the recent and the deep past. In this respect, we look forward to future studies focusing on OES beads, especially those led by our African colleagues.

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