

Unraveling the Topology of Knitted Fabrics

A framework based on knot theory links the robustness of textiles to the way defects propagate through them.

By **Rachel Berkowitz**

If a fabric unravels in just one spot, how likely is it to come fully undone? That's a question not only for textile artists but also for physicists, because it can be posed as one of topological defect propagation in a periodic structure. Daisuke Shimamoto at the University of Tokyo and his colleagues have now provided a topological framework to answer it [1]. Using techniques from knot theory, the researchers evaluated whether a textile's pattern is "knittable" and whether defects can easily disentangle it. Their analysis provides a tool for designing fabrics with controllable damage resistance.

Knitted textiles are periodic structures in which a single strand of yarn is arranged in rows interconnected by loops. They are created by manipulating the yarn locally while its two ends are pinned. To examine whether a given textile is indeed knitted according to this definition and to evaluate its mechanical robustness, Shimamoto and colleagues modeled textiles as rectangular grids of repeating unit cells. Next, they introduced defects by transforming individual unit cells into locally

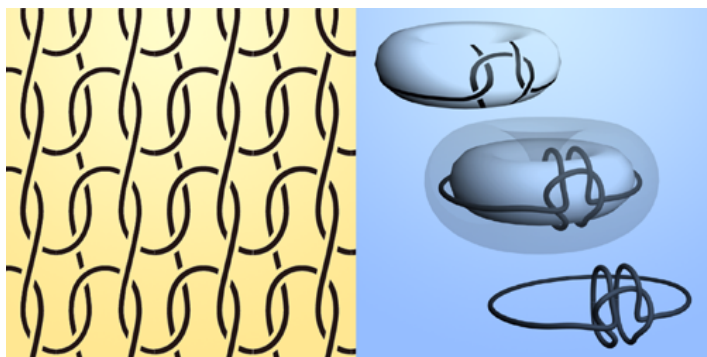
disentangled versions. Finally, they connected the two ends of the yarn by folding the textile into a torus and assessed the trivialness of the resulting knot structure. Knittable fabric treated in this way yielded only trivial knots, meaning the defects propagated between unit cells. In contrast, unknittable fabrics yielded complex knots, which were robust against defect propagation.

By comparing different textile patterns, Shimamoto and colleagues found that a knitted fabric unravels completely when spanned by a continuous line of defects. Further analysis showed that a fabric's robustness can be tuned by designing the defect-propagation pattern, paving the road for failure-aware functional fabrics.

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REFERENCES

1. D. S. Shimamoto *et al.*, "Topological defect propagation to classify knitted fabrics," *Phys. Rev. X* **16**, 031006 (2026).



Credit: D. S. Shimamoto *et al.* [1]