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Enhancing interdisciplinary impact of soft matter with a new npj journal

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The research field of soft matter is highly interdisciplinary, with its strong connections to chemistry, physics, engineering, biology and even biomedical research widely known and highly appreciated[1]. Less known are soft matter connections to scientifically much more distant cosmology and particle physics and pure mathematics, among many other research areas farther afield[2]. To help nurture, expand and celebrate this highly interdisciplinary scope of the soft matter research, a new *npj Soft Matter* journal is created. It will aim to serve soft matter community while making its research breakthroughs also highly visible to researchers outside of this field itself, fostering research connections between the soft matter researchers and ones from a wide variety of other fields.

The science and technology of the soft matter research field is an interdisciplinary pursuit of the scientific study and application of soft materials[1] that requires dealing with phenomena on a hierarchy of length and time scales, ranging from the atomic to those of biological systems, and often even to extraterrestrial scales in the context of the application potential. At small scales, quantum mechanical effects determine molecular structure and fundamental interactions between the constituent building blocks[1]. On each scale of increasing length or time, a variety of new phenomena appear, many of which are emergent - simply put, not calculable or even imaginable on the basis of behavior at smaller scales, even if that behavior is well understood. Soft matter is something of a "poster child" for emergence, with its structural diversity and physical behavior impossible to predict on the basis of atomic or molecular structure, or other properties of constituent building blocks.

Pierre-Gilles de Gennes (1991 Nobel prize in physics) referred to soft matter as "All physico-chemical systems that have large response functions"(with mild external influences leading to big effects)[3]. Indeed, an aspect of soft materials systems that is the key to their fundamental importance and technological utility is the emergence of certain aspects of "softness" from interactions of the constituent molecules or other building blocks (e.g., nanoparticles, micelles, interfaces, cells) which are weak, e.g., comparable in strength to thermal fluctuations. As a result, as the length scale increases, forms of self-assembled matter appear that are easily affected by external stimuli (mechanical stress, electric or magnetic fields, variation in temperature or chemical composition, optical illumination, etc.), making them responsive and, thus, practically very useful. Structures that are hierarchically self-organized over a range of length scales (nanometer to macroscopic) spontaneously appear or can be made, yielding the possibility of life, and, more recently, advanced technologies, ranging from fabrics and plastics, to information displays and portable computing. Understanding each soft matter scale requires the inspiration and creation of entirely new concepts, laws, and generalizations. Hence, the study of soft materials is not a branch of physics, or of chemistry, or of biology, nor is it a subfield of engineering. Rather it is an intrinsically interdisciplinary mixture of these, a pursuit in which progress is made only in the context of all of these fields. Furthermore, soft matter research often benefits from additional cross-pollination involving even other diverse research areas ranging from pure math to particle physics and to cosmology[2]. Thus, by its very nature soft materials science and engineering require an interdisciplinary scope. While technological applications of soft matter systems are abundant, their biomimetic nature and facile responsiveness to weak external stimuli make these systems suitable in solving Global problems of growing energy demand & climate change. By designing soft matter composite metamaterials with structure controllable at the mesoscale, unusual, highly desirable material properties can be obtained, including ones needed for sustainable development.

Among well-known contributors to the soft matter research field one can find some of the most famous scientists of all times, including Albert Einstein (his PhD dissertation and one of 1905 famous papers explained Brownian motion and introduced the "colloidal atom" paradigm[4]), Max Born (ferroelectric nematic liquid crystal theories 100 years ahead of their experimental discovery)[5–8], Flory, de Gennes, and many other Nobel laureates in Physics and Chemistry[1]. At the same time, the systems of study in soft matter research often include the systems that we encounter in our life on a day-to-day basis: liquid crystals, polymers, colloids, plastic crystals, biological membranes, biopolymers, block copolymers, molecular monolayers, colloids, nanoparticle suspensions, emulsions, foams, gels, elastomers, ferrofluids, granular materials, cells, tissues, filamentous networks, electro-rheological fluids, paints, foods, inks, cosmetics and many other soft materials[1].

While the interdisciplinarity at the level of physics and chemistry of material and biological systems is defining the very nature of soft matter as a research area[1], how can we expect connections between these fragile forms of matter and conceptually very distant particle physics or pure math or cosmology? It turns out that very fruitful connections between such diverse fields can arise from universality of phenomena[2]. For example, it has been long appreciated that the mechanisms of emergence and dynamics of defects at the nematic-isotropic liquid phase transition can exhibit behavior similar to that of cosmic strings in the Early Universe Cosmology (soon after the Big Bang, a cosmological analog of a phase transition)[9]. More recently, it has been shown that even interaction of light with cosmic strings has a very close analogy in the system of a liquid crystal with a vortex line[10]. On the other hand, liquid crystal and magnetic colloidal hopfions have close topological analogues in theoretical models of glueballs[2,11], the hypothetic particles comprised solely of gluons that soon may be the next big discovery after the Higgs boson. On the other hand, accessible to experimental exploration knotted vortices in common media like water as well as topological solitons and vortex knots in liquid crystals vividly visualize many concepts of mathematical knot theory[12,13]. Nurturing highly interdisciplinary soft-matter-centered research may help in creating new research fields and paradigms, as well as may help soft matter scientists contribute to the development of metamaterials, energy efficiency and sustainability[14]. To highlight such soft-matter-centric highly interdisciplinary research efforts will be among the missions of *npj Soft Matter*. In fact, one of the articles being published in the current issue is a very good example of such interdisciplinary work, providing graph-theoretical mathematical insight into the role that geometric features play in the collective mechanical behavior of anisotropic networks[15].

The new *npj Soft Matter* journal is a fully open access publication venue interested in disseminating results of rigorous, high-caliber research based on bold new ideas, leading to significant advances in the soft matter field and beyond. Our editorial team's vision is for *npj Soft Matter* to become a premier and highly visible platform for publishing groundbreaking soft matter research. We aim to inspire scientific breakthroughs and technological innovation across disciplines linked to soft matter and respective applications. The npj series of journals highlight where the current hot areas of research are, such as *npj Artificial Intelligence* and *npj Quantum Materials*, and it is great that the soft matter research field is now amongst them. Providing the soft matter community with open-access high-visibility publishing opportunities, we anticipate, will help our research field grow and make a positive impact on a large variety of disciplines.

An existing and well-known "*Soft Matter*" journal is published by the Royal Society of Chemistry (RSC)[3]. The *npj Soft Matter* will differ from its RSC counterpart primarily in that it will be a fully online open-access publication. Being part of the npj journal series, this new journal will strive to assure both quality and very high visibility of published articles not just within the soft matter community itself, but more broadly, across the entire spectrum of science and engineering fields.

Data availability

There is no dataset associated with this article.

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References

1. Chaikin, P. M. & Lubensky, T. C. *Principles of Condensed Matter Physics* (Cambridge University Press, 1995).
2. Smalyukh, I. I. Review: knots and other new topological effects in liquid crystals and colloids. *Rep. Prog. Phys.* **83**, 106601 (2020).
3. Soft matter: more than words. *Soft Matter* **1**, 16 (2005).
4. Smalyukh, I. I. Liquid crystal colloids. *Annu. Rev. Condens. Matter Phys.* **9**, 207–226 (2018).
5. Born, M. Über anisotrope Flüssigkeiten. Versuch einer Theorie der flüssigen Kristalle und des elektrischen Kerr-Effekts in Flüssigkeiten. *Sitzungsber. Preuss. Akad. Wiss.* **30**, 614–650 (1916).
6. Mandle, R. J., Cowling, S. J. & Goodby, J. W. A nematic to nematic transformation exhibited by a rod-like liquid crystal. *Phys. Chem. Chem. Phys.* **19**, 11429–11435 (2017).
7. Nishikawa, H. et al. A fluid liquid-crystal material with highly polar order. *Adv. Mater.* **29**, 1702354 (2017).
8. Chen, X. et al. First-principles experimental demonstration of ferroelectricity in a thermotropic nematic liquid crystal: polar domains and striking electro-optics. *Proc. Natl. Acad. Sci. USA* **117**, 14021–14031 (2020).
9. Bowick, M. J., Chandar, L., Schiff, E. A. & Srivastava, A. M. The cosmological Kibble mechanism in the laboratory: string formation in liquid crystals. *Science* **263**, 943–945 (1994).
10. Meng, C., Wu, J.-S. & Smalyukh, I. I. Topological steering of light by nematic vortices and analogy to cosmic strings. *Nat. Mater.* **22**, 64–72 (2023).
11. Ackerman, P. J. & Smalyukh, I. I. Static 3D knotted solitons in fluid chiral ferromagnets and colloids. *Nat. Mater.* **16**, 426–432 (2017).
12. Kleckner, D., Kauffman, L. H. & Irvine, W. T. M. How superfluid vortex knots untie. *Nat. Phys.* **12**, 650–655 (2016).
13. Tai, J.-S. B. & Smalyukh, I. I. Three-dimensional crystals of adaptive knots. *Science* **365**, 1449–1453 (2019).
14. Nature Research Custom Media & SKCM². Untangling pressing global problems using knots. https://www.nature.com/articles/d42473-023-00423-y (2025).
15. Reyes-Martinez, M. A. et al. Graph-theoretical description and continuity problems for stress propagation through complex strut lattices. *npj Soft Matter* this issue (2025).

Competing interests

The author declares no competing interests.