Advent of torsional optomechanics from Beth's legacy

Jaehyuck Jang,[a] Jungho Mun,[b] and Junsuk Rho[a,b,c,*]
[a]Pohang University of Science and Technology (POSTECH), Department of Chemical Engineering, Pohang, Republic of Korea
[b]Pohang University of Science and Technology (POSTECH), Department of Mechanical Engineering, Pohang, Republic of Korea
[c]POSCO-POSTECH-RIST Convergence Research Center for Flat Optics and Metaphotonics, Pohang, Republic of Korea

Torsional optomechanics, which involves the transfer of angular momentum from light to matter, has been a vibrant research area since Beth's pioneering contribution in 1935. Beth proposed a method to measure the transfer of spin angular momentum using a torsional pendulum,[1] laying the foundation for classical and quantum optomechanics related to particle levitation, trapping, and cooling in modern optics.[2]

In the article recently published in *Advanced Photonics*, Brasselet reviewed the Beth's discovery legacy and looked how this idea has continued over the years.[3] Beth successfully detected the spin angular momentum of light using a torsion pendulum consisting of half-wave plates and a mirror.[1] Years later, Carrara proposed a modified configuration making the detection easier by introducing the system in the microwave domain.[4] In 1966, Allen devised an experimental setup with a drop-suspended aluminum dipole hanging on a support, enclosed by a circular waveguide.[5] The rotation of the dipole was measured by monitoring the rotational spectral shift of dipole radiation. This optically induced rotation is now considered as a cornerstone of optical tweezers. In 1992, Allen et al. conducted an orbital analog of the spin experiment by Beth, measuring the mechanical torque induced by the transfer of orbital angular momentum from a paraxial Laguerre-Gaussian beam to a suspended pair of cylindrical lenses.[6] In 2007, Battacharya and Meystre achieved the quantization of a vibrational and rotational mode of a classical oscillator through angular momentum transfer,[7] which is an important contribution to the field of quantum optomechanics.

Beth's accomplishment a century ago has directly or indirectly influenced various fields, including classical and quantum optomechanics, spin-orbit interactions, as well as acoustomechanics (Fig. 1). Torsional optomechanics, driven by the exchange of orbital angular momentum, has been actively investigated in recent days, particularly with the advent of the field of optical vortices.[8] Cavity quantum optomechanics offers a potential playground for exploring the fundamental principles of quantum mechanics in macroscopic systems, with potential applications in highly sensitive devices for detecting forces, displacements, and other physical quantities.[9] With the advent of optical vortices with orbital angular momentum,[6,8] the spin and orbital parts of angular momentum have been distinguished, and their interplay, or the optical spin-orbit interactions, have been actively investigated[10] for spin and orbital Hall effect of light, spin-orbit conversion, and chiral sensing. Similarly, exchanges of angular momentum were found in acoustics,[11,12] and the spin part of angular momentum of acoustics has recently been noted.[13] Recently, there has been investigation into the torsional dynamics driven by acoustic radiation torque.[11] Wireless torsional mechanics driven by acoustic fields has been applied to ultrasound elastography and viscoelastic tensor imaging.[12] Additionally, recent studies in acoustomechanics hold promise for the development of new imaging technologies in metrology and biomedical imaging.[12] The detailed overviews and perspectives on these fields can be found in Brasselet's article.[3] In conclusion, we would like to quote Brasselet, who aptly states that "Beth's legacy is not yet over." As such, Beth's pioneering contribution continues to bloom as it has for over a century.

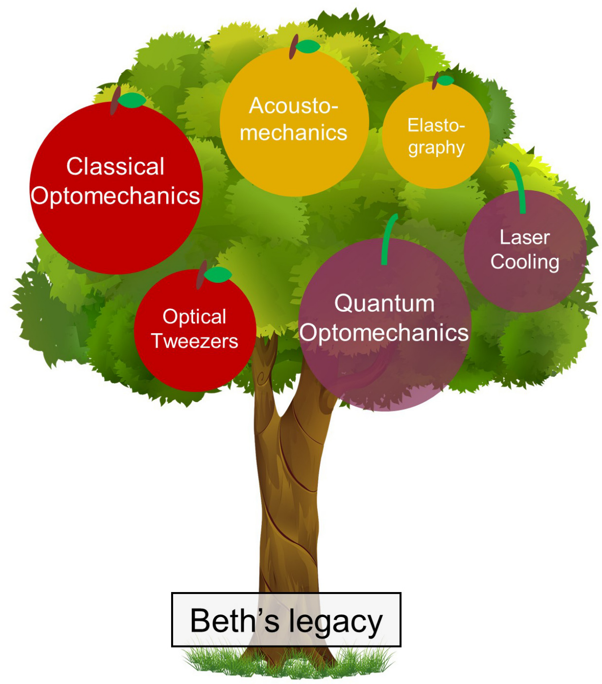

Fig. 1 Illustration of the impact of Beth's accomplishment on diverse fields.

*Address all correspondence to Junsuk Rho, jsrho@postech.ac.kr

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Jaehyuck Jang is a postdoctoral fellow in Chemical Engineering at Pohang University of Science and Technology (POSTECH). His research interests include planar optics and its applications for next-generation displays, high-*Q* optical resonators, and light-matter interactions between resonators and quantum emitters.

Jungho Mun is a POSTECH PIURI postdoctoral fellow in Mechanical Engineering at POSTECH. His current research interests include subwavelength electromagnetics, scattering, structured lights, and meta-optics.

Junsuk Rho is a Mu-Eun-Jae Endowed Chair Associate Professor and Young Distinguished Professor with a joint appointment in Mechanical Engineering and Chemical Engineering at POSTECH. He received his BS (2007) and MS (2008) degrees in Mechanical Engineering from Seoul National University and the University of Illinois, Urbana-Champaign, respectively. After getting his PhD (2013) in mechanical engineering and nanoscale science & engineering from the University of California Berkeley, he worked as a postdoctoral fellow in the Materials Sciences Division at Lawrence Berkeley National Laboratory and was an Ugo Fano Fellow in the Nanoscience and Technology Division at Argonne National Laboratory.