ZERO-STIFFNESS STRUCTURES

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The talk will provide a compendium of 'zero-stiffness' structures, describing three classes of structures that remain in a neutral state of equilibrium, even while they undergo large (and clearly geometrically non-linear) displacements, with part or all of each structure undergoing large (but elastic) deformations. The structures will not be abstract theoretical constructions, but real structures modelled using reasonable assumptions, and physical examples will be demonstrated.

The three structures described are at first sight very different:

> The first class of structures are simply beam structures with an axi-symmetric cross-section, stress-free when straight, bent into a torus: they then have no torsional stiffness. This lack of stiffness is not a new discovery: it was described in Thompson & Tait's 1883 'Treastice on Natural Philosophy'.
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> The second class of structures, by contrast, was discovered in our lab only recently: during work on prestressed bistable shell structures, we discovered that certain combinations of geometry and prestress could give a structure with no stiffness in a particular bending mode, even for large deformations.
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> The third class of structures are sometimes called 'statically-balanced' structures, and include as an example a properly constructed 'Anglepoise', or 'Luxo' lamp. The key to these structures is the use of springs that appear to have a zero rest-length. We have recently extended the range of possible structures of this type to include zero-stiffness 'tensegrity' structures.

The talk will describe each class of structure, and provide straightforward theory describing how each of the structures works.

Although the structures described are indeed very different, there are certain aspects that are common to them all. The talk will try to tease out a common symmetry theme.