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Elastic instabilities in rubber

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Materials that undergo large elastic deformations can exhibit novel instabilities. Several examples are described: development of an aneurysm on inflating a rubber tube; non-uniform stretching on inflating a spherical balloon; formation of internal cracks in rubber blocks at a critical level of triaxial tension or when supersaturated with a dissolved gas; surface wrinkling of a block at a critical amount of compression; debonding or fracture of constrained films on swelling, and formation of "knots" on twisting stretched cylindrical rods. These various deformations are analyzed in terms of a simple strain energy function, using Rivlin's theory of large elastic deformations, and the results are compared with experimental measurements of the onset of unstable states. Such comparisons provide new tests of Rivlin's theory and, at least in principle, critical tests of proposed strain energy functions for rubber. Moreover the onset of highly non-uniform deformations has serious implications for the fatigue life and fracture resistance of rubber components.

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