Abstract Submitted
for the MAR08 Meeting of
The American Physical Society

Buckling and force propagation in intracellular microtubules

MOUMITA DAS, Vrije Universiteit, ALEX J. LEVINE, University of California, Los Angeles, F.C. MACKINTOSH, Vrije Universiteit — Motivated by recent experiments [1] showing the buckling of microtubules in cells, we study theoretically the mechanical response of, and force propagation along elastic filaments embedded in a non-linear elastic medium. We find that embedded microtubules buckle when their compressive load exceeds a critical value f_c which is two orders of magnitude larger than for an isolated MT as found earlier [1], and that the resulting deformation is restricted to a penetration depth that depends on both the non-linear material properties of the surrounding cytoskeleton, as well as the direct coupling of the microtubule to the cytoskeleton possibly through MT-associating proteins (MAPS). The deformation amplitude depends on the applied load $f > f_c$ as $(f - f_c)^{1/2}$. This work shows how the range of compressive force transmission by microtubules can be as large as tens of microns, and is governed by the mechanical coupling to the surrounding cytoskeleton.

References:

[1] CP Brangwynne et al., J. Cell Biology, 173, 733 (2006).

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Date submitted: 23 Nov 2007

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