



**Universiteit
Leiden**
The Netherlands

Interactions from lipid membrane deformations

Azadbakht, A.

Citation

Azadbakht, A. (2024, January 11). *Interactions from lipid membrane deformations*. *Casimir PhD Series*. Retrieved from <https://hdl.handle.net/1887/3677414>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/3677414>

Note: To cite this publication please use the final published version (if applicable).

Interactions from Lipid Membrane Deformations

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op dinsdag 11 januari 2024
klokke 11.15 uur

door

Ali Azadbakht

geboren te Sari, Iran

in 1990

Promotor: Prof. dr. D.J. Kraft
Co-promotor: Dr. A. Morin

Promotiecommissie: Prof. dr. E. R. Dufresne (*Cornell University, Ithaca, VS*)
Dr. A. Šarić (*ISTA, Vienna, Austria*)
Prof. J. Aarts
Dr. L. Jawerth
Prof. dr. J. van Noort
Prof. dr. T. Schmidt

ISBN 978-90-8593-585-8

Casimir PhD-series, Delft-Leiden, 2023-39.

An electronic version of this thesis can be found at <https://openaccess.leidenuniv.nl>

The work described in this thesis was financed by the physics department at Leiden University.

Backcover: The cover shows a schematic simulation of colloidal particles (in green) on a soft plane (in magenta) that is deformed by the colloids. They represent a simplified model of proteins or inclusions that cause the deformation of cell membranes. Each chapter begins with a painting by Sanam Foroutanparsa.

Contents

1	Introduction	1
1.1	Lipid Membranes	2
1.2	Engulfment of objects	6
1.3	Membrane-mediated interaction	8
1.4	Aim and Outline of this thesis	13
2	Wrapping pathways of anisotropic dumbbell particles by giant unilamellar vesicles	17
2.1	Introduction	18
2.2	Materials and Methods	19
2.3	Results and Discussion	21
2.4	Conclusion	28
2.5	Appendices	29
3	Non-additive interactions between three membrane-wrapped spheres	43
3.1	Introduction	44
3.2	Materials and Methods	46
3.3	Results and Discussion	49
3.4	Conclusion	55
3.5	Supporting Figures	57
4	Repulsion and attractions in the interactions of inversely membrane-deforming particles	61
4.1	Introduction	62
4.2	Materials and Methods	63
4.3	Results and Discussion	65
4.4	Conclusion	72
4.5	Supporting Figures	72

5 Non-additivity in many-body interactions increases disorder of membrane-deforming spheres	75
5.1 Introduction	76
5.2 Methods and Materials	77
5.3 Results and Discussion	80
5.4 Conclusion	88
5.5 Appendices	90
6 Shape matters: curvature-mediated interactions between anisotropic particles	95
6.1 Introduction	96
6.2 Materials and Methods	97
6.3 Results and Discussions	100
6.4 Conclusion	107
6.5 Supporting Figures	109
Bibliography	111
Samenvatting	127
Summary	131
List of Publication	135
Acknowledgements	137
Curriculum Vitae	139