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STRUCTURAL STABILITY OF 65803 DIDYMOS: INSIGHTS FROM SPH SIMULATIONS

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Europlanet Science Congress (EPSC 2021)

Virtual meeting, 13 – 24 September 2021

NEO-MAPP

HORIZON 2020

FNSNF

Introduction

The binary asteroid 65803 Didymos-Dimorphos is the target of NASA’s DART [1] and ESA's Hera missions [2].

The interior structure of Didymos is crucial for our understanding of its stability. Without cohesion and with an estimated bulk density of 2.1 g/cc, Didymos is not able to keep its shape stable [3, 4] and thus, cohesive forces might be present in its structure [5].

For the results presented here, we simulate the rotating asteroid and investigate its physical properties. We assume that Didymos has a homogeneous structure. We perform simulations using a range of values for the cohesion (c) and the internal friction coefficient (f) and evaluate Didymos’ stability.

Bern's SPH code

- 3D shape model based on light curves
- We used Bern's Smooth Particle Hydrodynamics (SPH) code [6, 7], which includes
  - pressure-dependent strength model
  - friction, cohesion, porosity
  - self-gravity

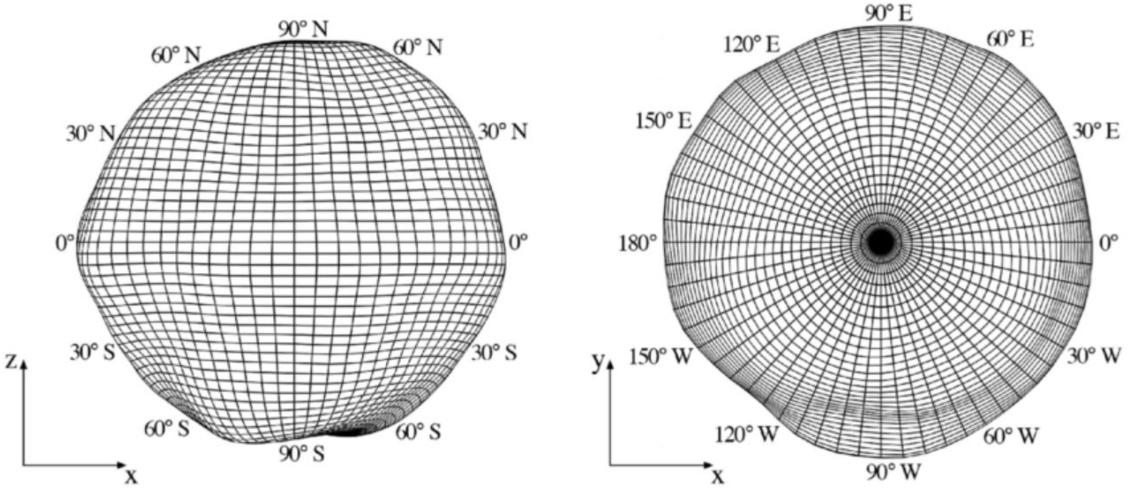

Figure 1: Shape model of Didymos [8]

Bulk density	Rotation period	Cohesion, c	Friction, f
2.1 g/cc	2.26 h	0.1 - 100 Pa	0.4 - 1.0

Table 1: Range of parameters for all simulations

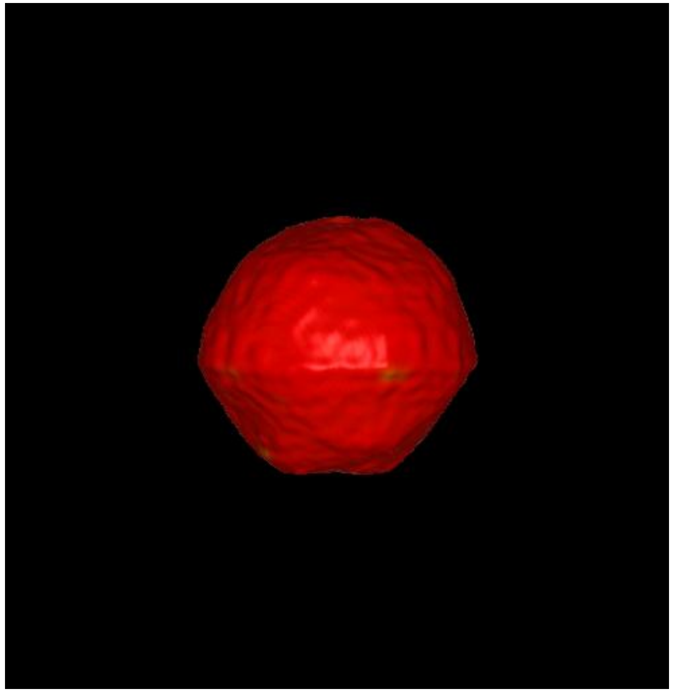

Figure 2: Initial setup of Didymos

Results: examples of simulation outcomes

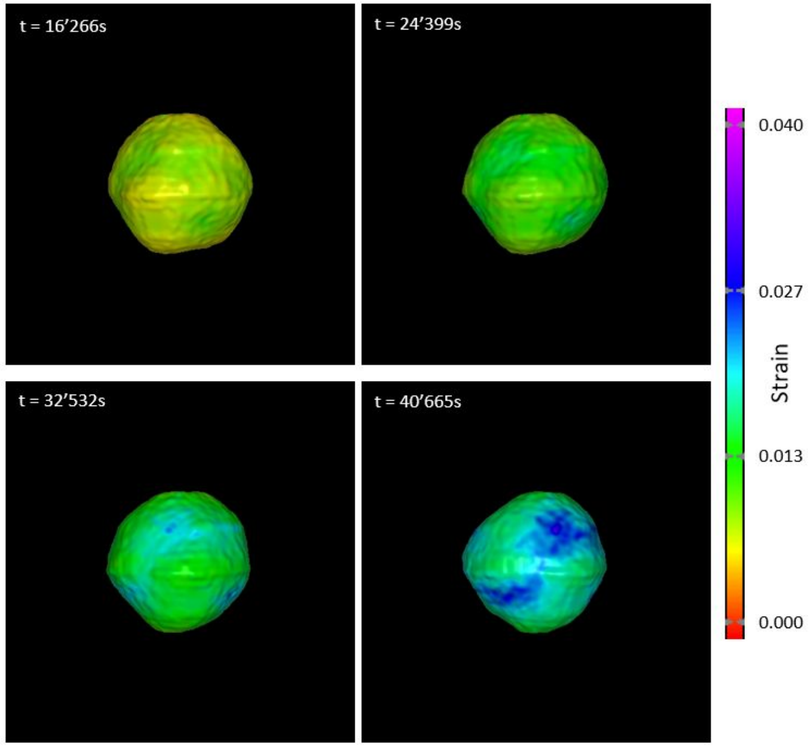

Figure 3: *f = 0.4 and c = 60 Pa*

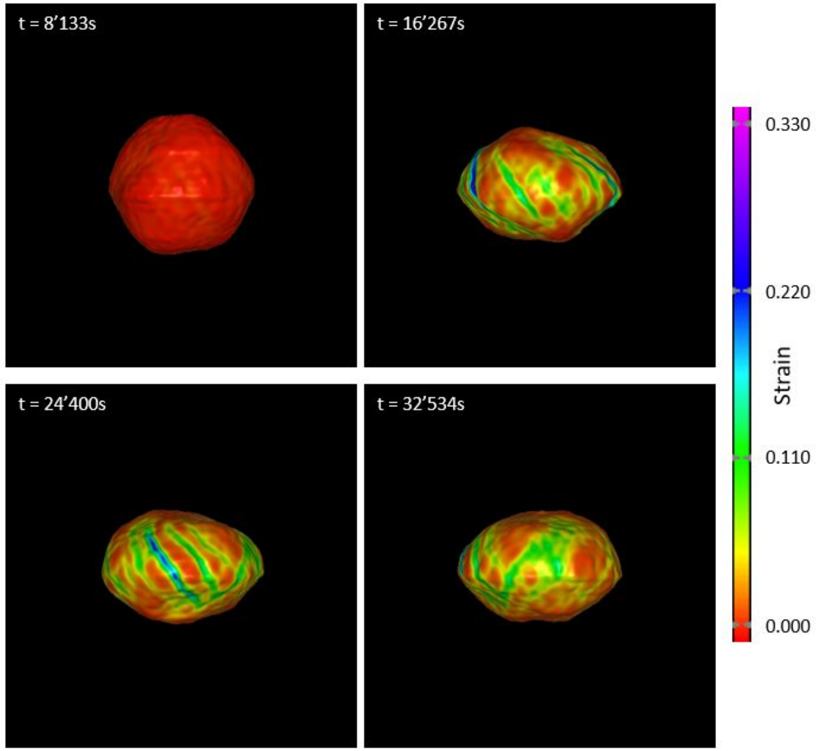

Figure 4: *f = 0.8 and c = 10 Pa*

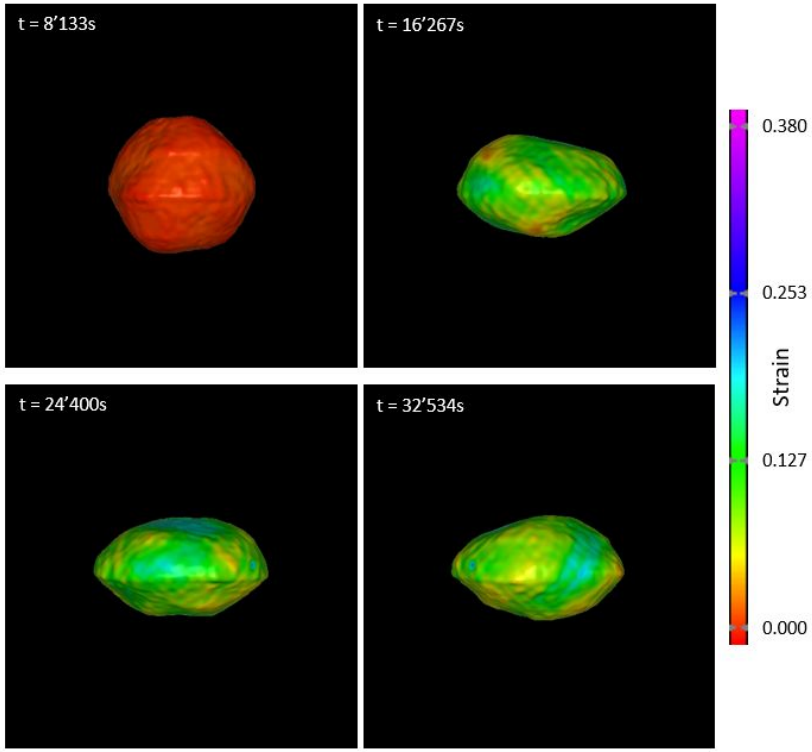

Figure 5: *f = 1.0 and c = 1 Pa*

- Stability criteria: 90% of particles have strain ≤ 0.1
- Stable case: Figure 3 (f = 0.4 and c = 60 Pa)
- Semi-stable case: Figure 4 (f = 0.8 and c = 10 Pa)
- Unstable case: Figure 5 (f = 1.0 and c = 1 Pa)

-> Notice the different colour scales for Figures 3, 4 and 5

Results and discussion

c [Pa] / f	0.4	0.6	0.8	1
0.1	0.0%	0.0%	0.0%	0.0%
1	0.0%	0.0%	0.0%	0.2%
10	12.6%	21.1%	30.1%	38.1%
20	34.0%	39.3%	100.0%	95.6%
40	100.0%	100.0%	100.0%	100.0%
60	100.0%	100.0%	100.0%	100.0%
80	100.0%	100.0%	100.0%	100.0%
100	100.0%	100.0%	100.0%	100.0%

Table 2: *Percentage of particles with strain ≤ 0.1. Stable cases are highlighted in green.*

- The total accumulated strain decreases for increasing cohesion.
- The transition from unstable to stable structures is between 20-40 Pa, depending on the friction coefficient.

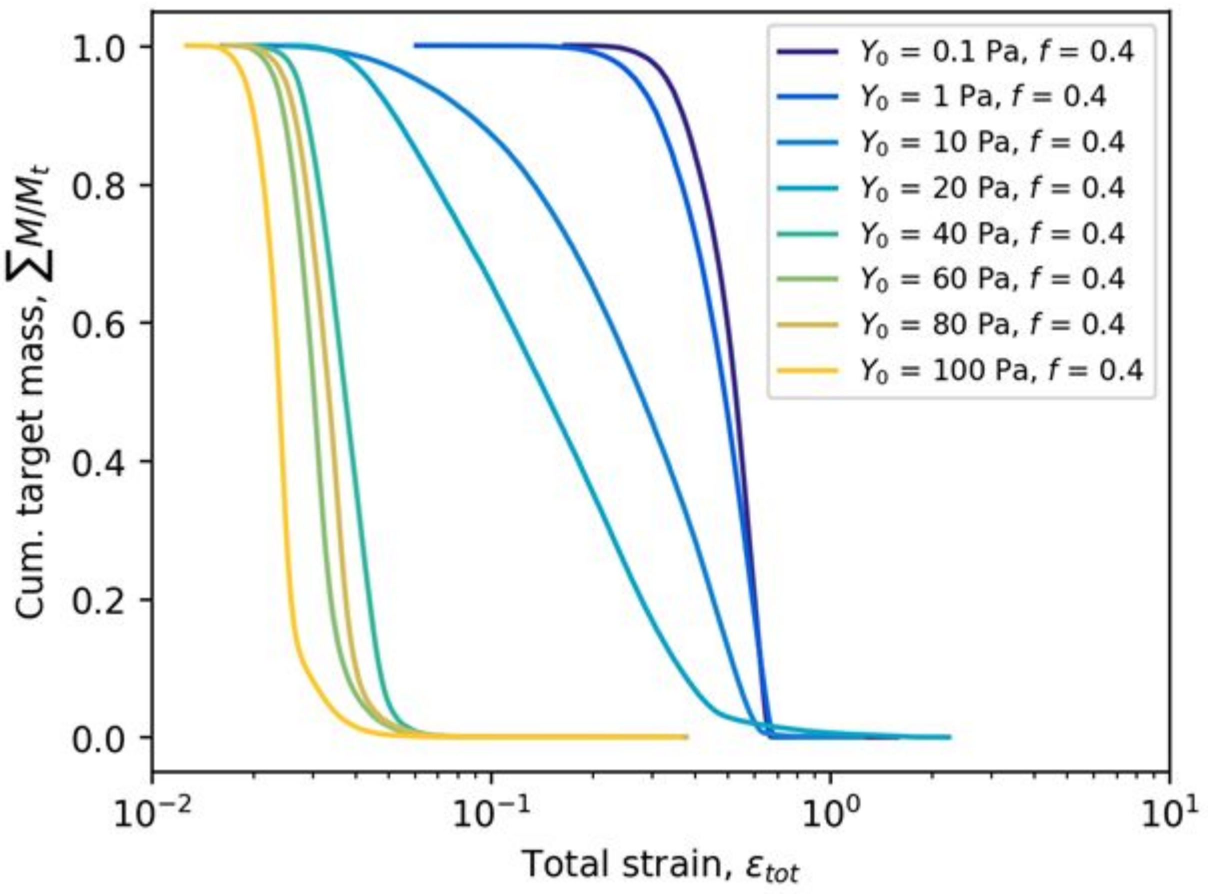

Figure 6: *Total strain for all simulations with f = 0.4.*

Conclusions

- For a cohesion of ≳ 40 Pa all simulations lead to stable structures, regardless of the coefficient of internal friction.
- The threshold for semi-stable cases is c = 10 to 20 Pa.
- The higher the friction coefficient, the lower the cohesion to obtain stable structures.
- Some simulations showed signs of breakup (e.g. crevices seen in Figure 4).

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Acknowledgements: This work has received funding from the European Union's Horizon 2020 research and innovation programme, NEO-MAPP, under grant agreement No. 870377