

HOW TO KICKSTART PLANETS:

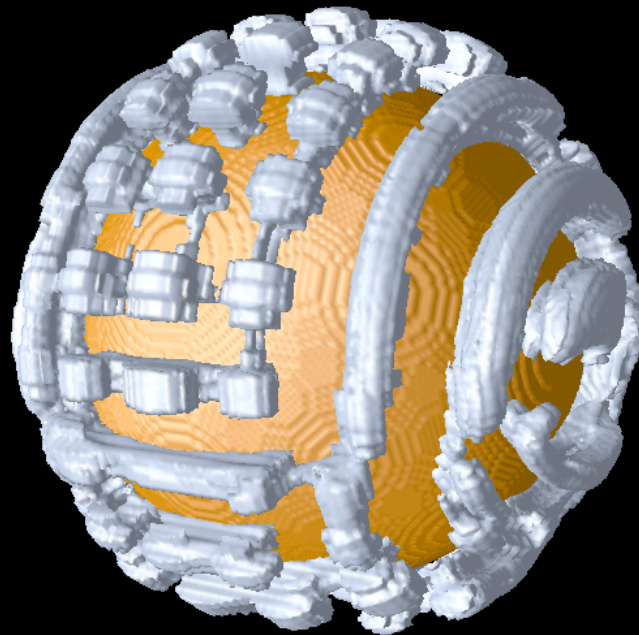
***ON THE INFLUENCE OF
THE INITIAL CONDITIONS***

R ZIETHE & J BENKHOFF

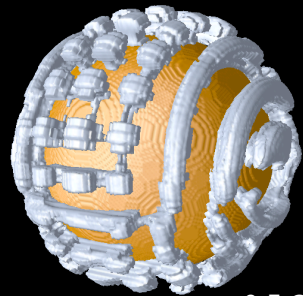
INTERNATIONAL CONFERENCE ON COMPARATIVE PLANETOLOGY

11 - 15 MAY 2009, ESA-ESTEC, NOORDWIJK, NETHERLANDS

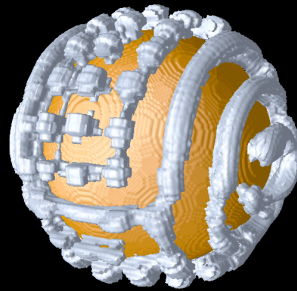
MOTIVATION



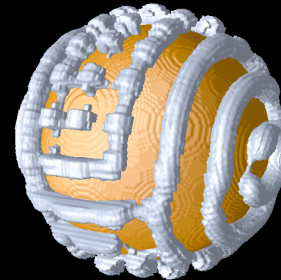
MOTIVATION



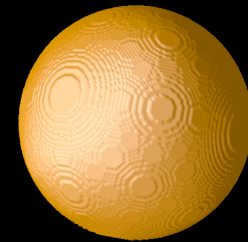
0.5 Ga



1.0 Ga

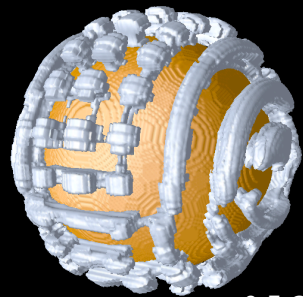


2.0 Ga

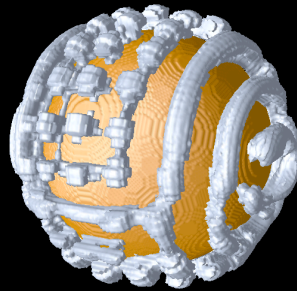


4.5 Ga

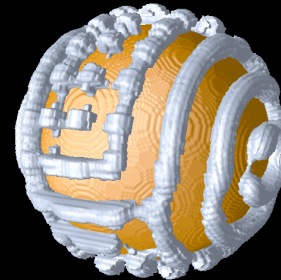
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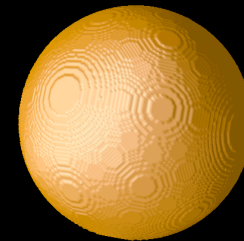
0.5 Ga



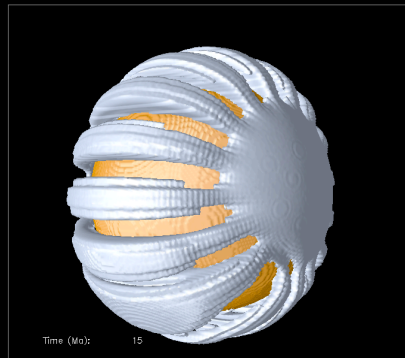
1.0 Ga



2.0 Ga



4.5 Ga



Time (Ma): 15



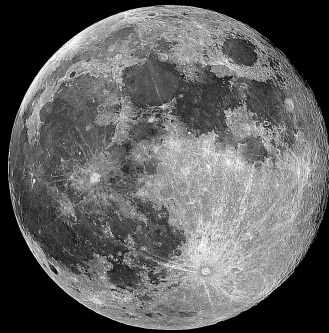
Time (Ma): 263

<i>Planet</i>	<i>R_p [km]</i>	<i>R_c [km]</i>	<i>R_c/R_p</i>	<i>d'</i>
<i>Venus</i>	<i>6050</i>	<i>2800</i>	<i>0.46</i>	<i>0.54</i>
<i>Earth</i>	<i>6400</i>	<i>3500</i>	<i>0.55</i>	<i>0.45</i>
<i>Mars</i>	<i>3400</i>	<i>1700</i>	<i>0.5</i>	<i>0.5</i>
<i>Mercury</i>	<i>2440</i>	<i>1900</i>	<i>0.78</i>	<i>0.22</i>
<i>Moon</i>	<i>1740</i>	<i>400</i>	<i>0.23</i>	<i>0.77</i>

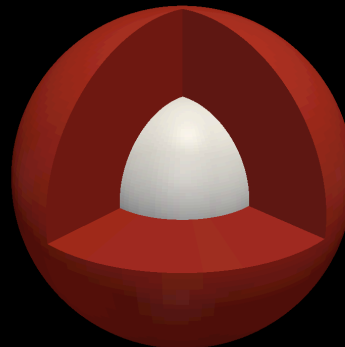
<i>Planet</i>	<i>R_p [km]</i>	<i>R_c [km]</i>	<i>R_c/R_p</i>	<i>d'</i>
<i>Venus</i>	<i>6050</i>	<i>2800</i>	<i>0.46</i>	<i>0.54</i>
<i>Earth</i>	<i>6400</i>	<i>3500</i>	<i>0.55</i>	<i>0.45</i>
<i>Mars</i>	<i>3400</i>	<i>1700</i>	<i>0.5</i>	<i>0.5</i>
<i>Mercury</i>	<i>2440</i>	<i>1900</i>	<i>0.78</i>	<i>0.22</i>
<i>Moon</i>	<i>1740</i>	<i>400</i>	<i>0.23</i>	<i>0.77</i>

THE CANDIDATES

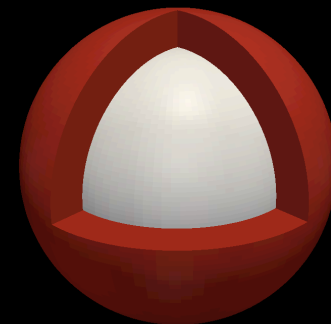
Moon



Mars



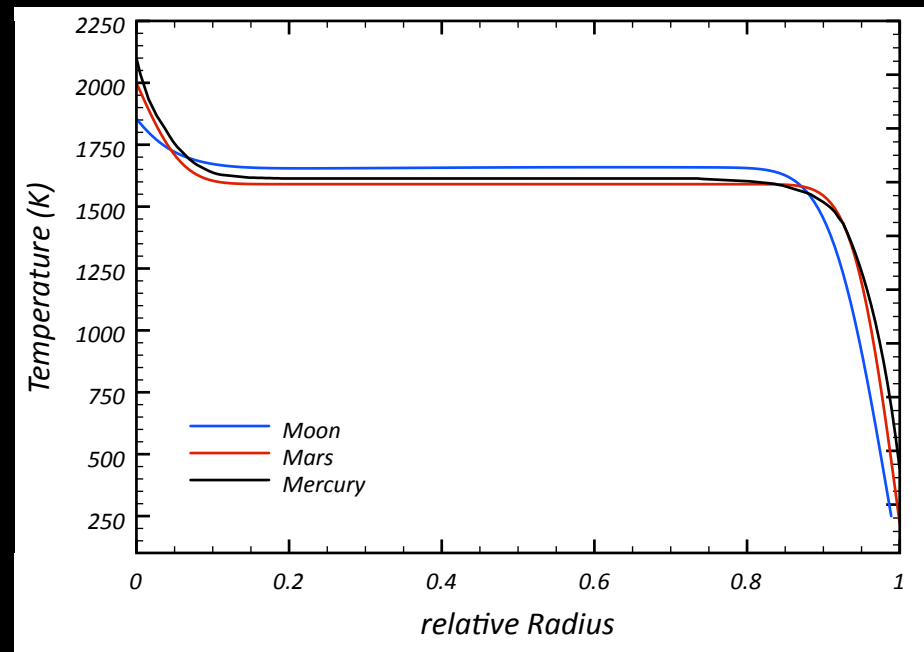
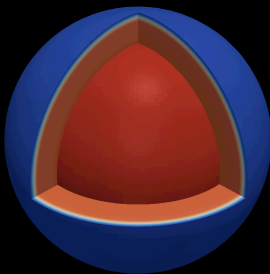
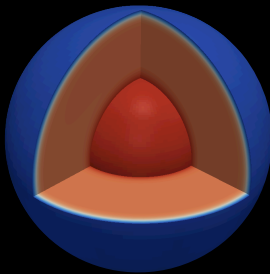
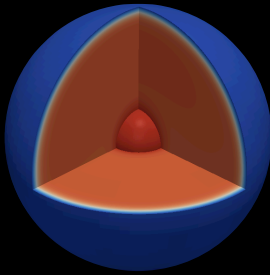
Mercury



THE CANDIDATES' PARAMETERS

		Moon	Mars	Mercury
				
Planet radius	R_p [km]	1740	3400	2440
Core Radius	R_c [km]	390	1700	1900
Mantle thickness	d [km]	1350	1700	540
Surface gravity	g [ms^{-2}]	1.62	3.5	3.8
Mantle density	ρ [kgm^{-3}]	3300	3600	2800
Heat production rate	Q_0 [Wkg^{-3}]	5×10^{-12}	5×10^{-12}	1.6×10^{-11}
Surface temperature	T_{surf} [K]	250	220	440
Core temperature	T_{core} [K]	1900	2000	2100
Thermal conductivity	k [$Wm^{-1}K^{-1}$]		4	
Thermal diffusivity	κ [$m^{-2}s^{-1}$]		10^{-6}	
Specific heat mantle	c_{pm} [$JK^{-1}kg^{-1}$]		1000	
Specific heat core	c_{pc} [$JK^{-1}kg^{-1}$]		695	
Thermal expansion coefficient	α [K^{-1}]		2×10^{-5}	
Reference viscosity	η_0 [Pas]		1021	
Activation temperature	A [K]		40'000	

INITIAL CONDITIONS



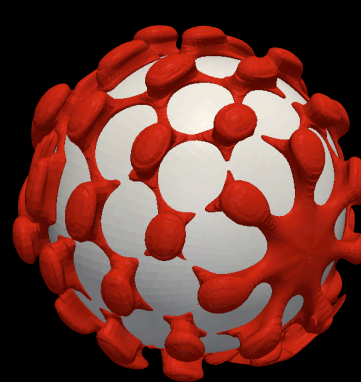
INITIAL PERTUBATION



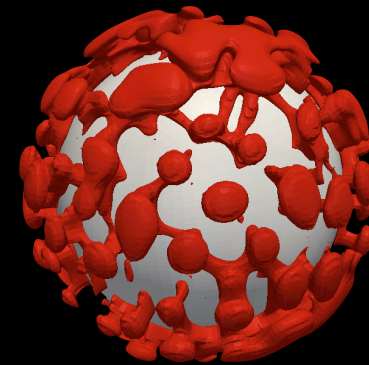
$l = 19$
 $m = 0$



$l = 19$
 $m = l$



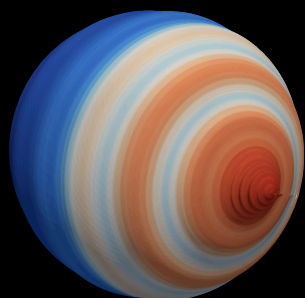
$l = 19$
 $m < l$



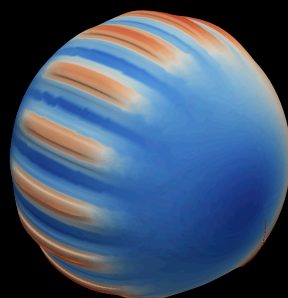
$l = 29$
 $m = \text{random}$

FIRST REALITY CHECK

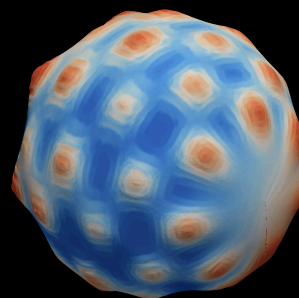
Topography



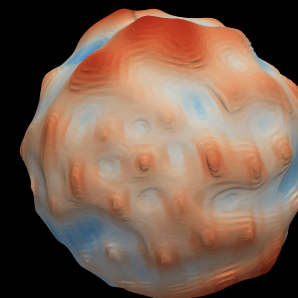
2700 m 360 m -490 m



2800 m 400 m -750 m

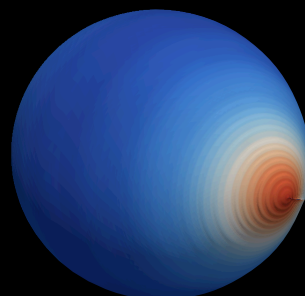


2200 m -500 m -1400 m

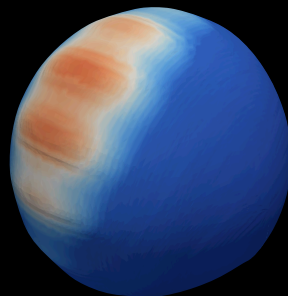


1200 m 150 m -1500 m

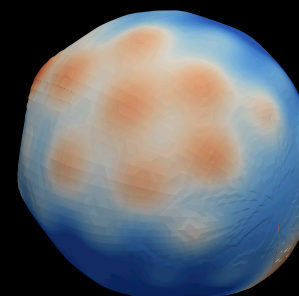
Geoid



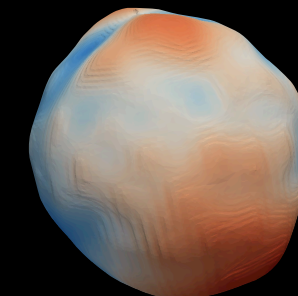
440 m 190 m -70 m



490 m 150 m -190 m



320 m 0 m -280 m



200 m 0 m -200 m

LUNAR MODELS (STATIONARY)

$l = 1$



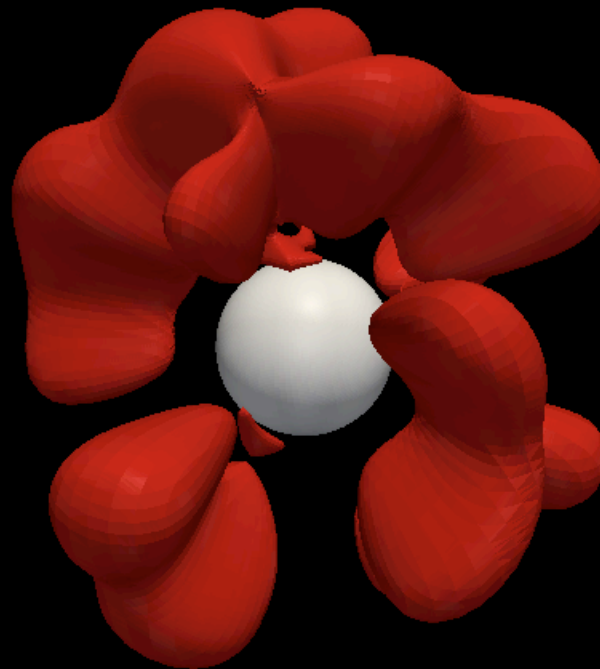
LUNAR MODELS (STATIONARY)

$l = 3$

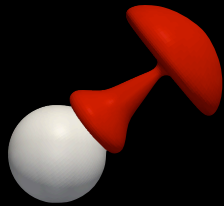


LUNAR MODELS (STATIONARY)

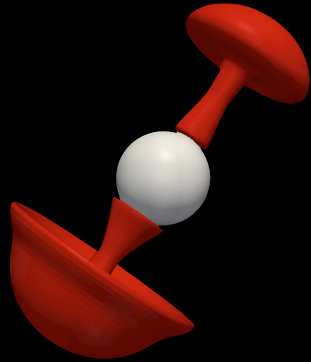
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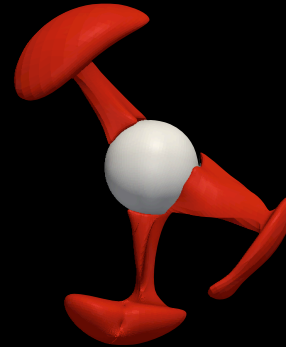
LUNAR MODELS (STATIONARY)



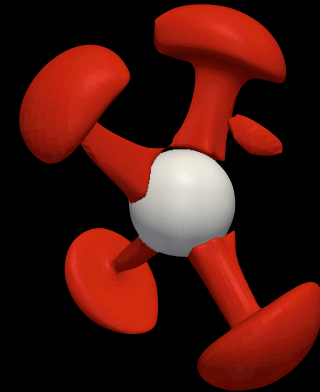
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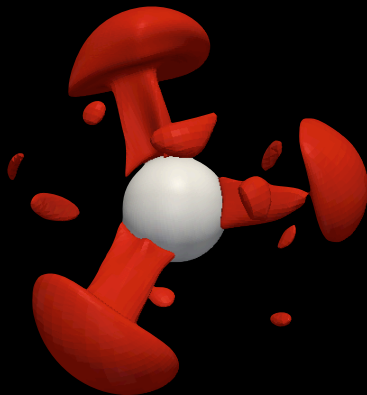
$l = 2$



$l = 3$



$l = 4$



$l = 5$



$l = 6$



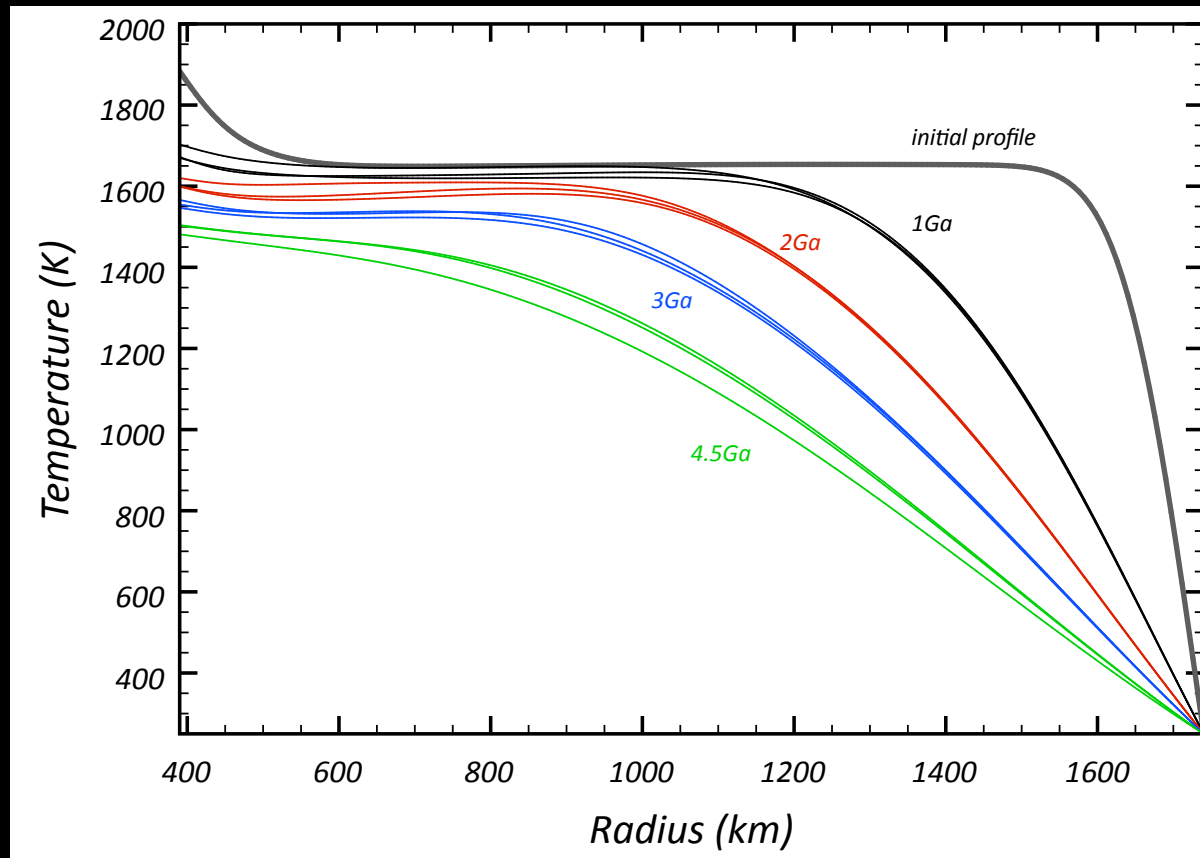
$l = 7$



$l = 8$

LUNAR MODELS (EVOLUTION)

$l = 1,3,8$



consistent with Spohn et al (2001) and Ziethe et al (2009)

LUNAR MODELS (EVOLUTION)

$$l = 3$$

LUNAR MODELS (EVOLUTION)

$$l = 8$$

LUNAR MODELS (EVOLUTION)

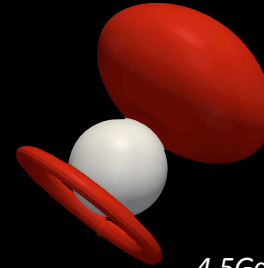
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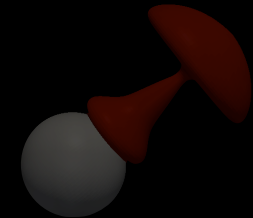
0.1Ga



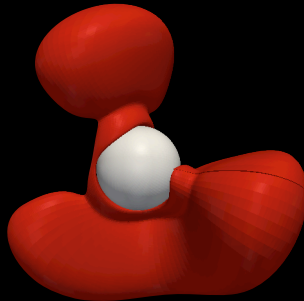
2.0Ga



4.5Ga



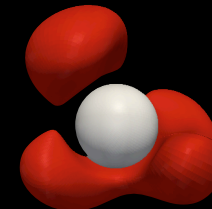
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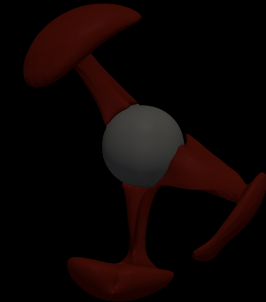
0.1Ga



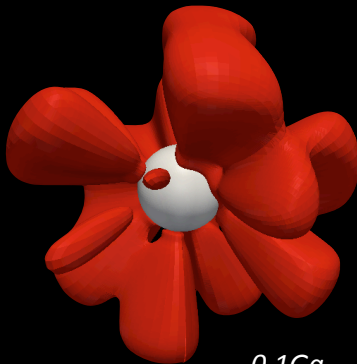
2.0Ga



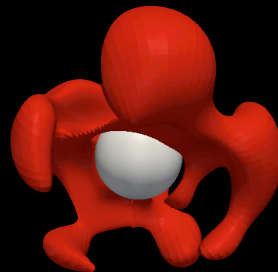
4.5Ga



$l = 8$



0.1Ga



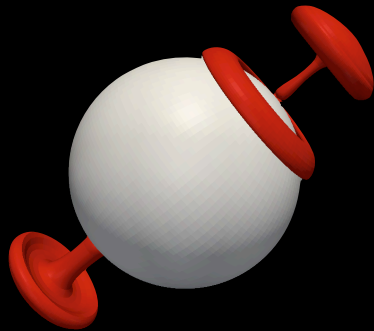
2.0Ga



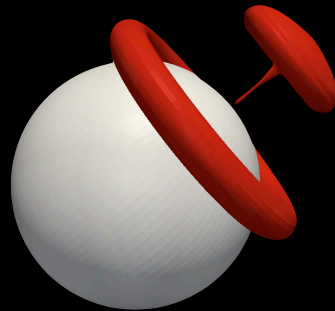
4.5Ga



MARTIAN MODELS (STATIONARY)



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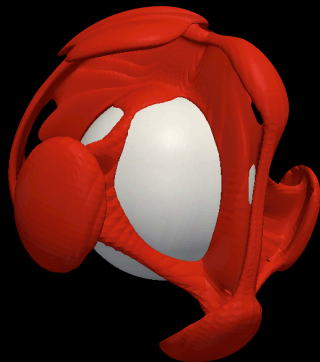
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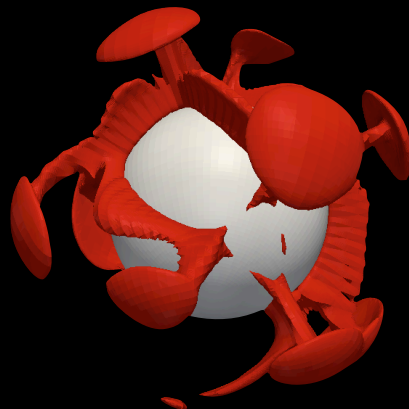
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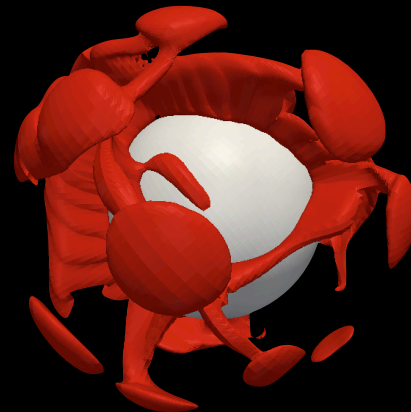
$l = 4$



$l = 5$



$l = 6$



$l = 7$



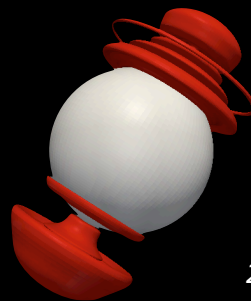
$l = 8$

MARTIAN MODELS (EVOLUTION) PRELIMINARY!!!

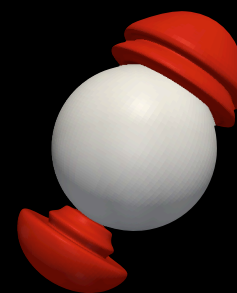
$l = 2$



0.1Ga

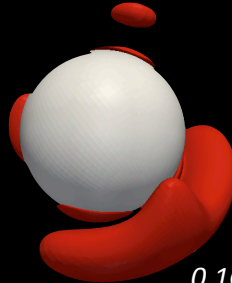


2.0Ga



4.5Ga

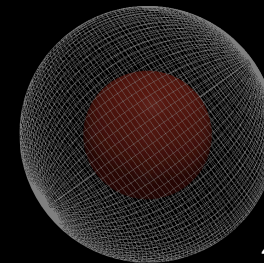
$l = 4$



0.1Ga

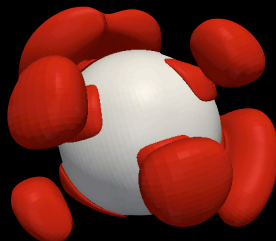


2.0Ga

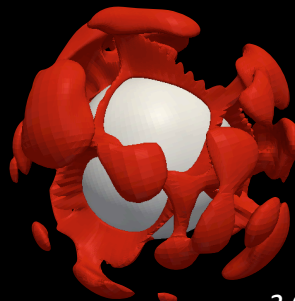


4.5Ga

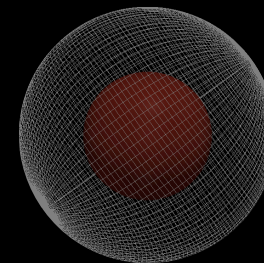
$l = 6$



0.1Ga

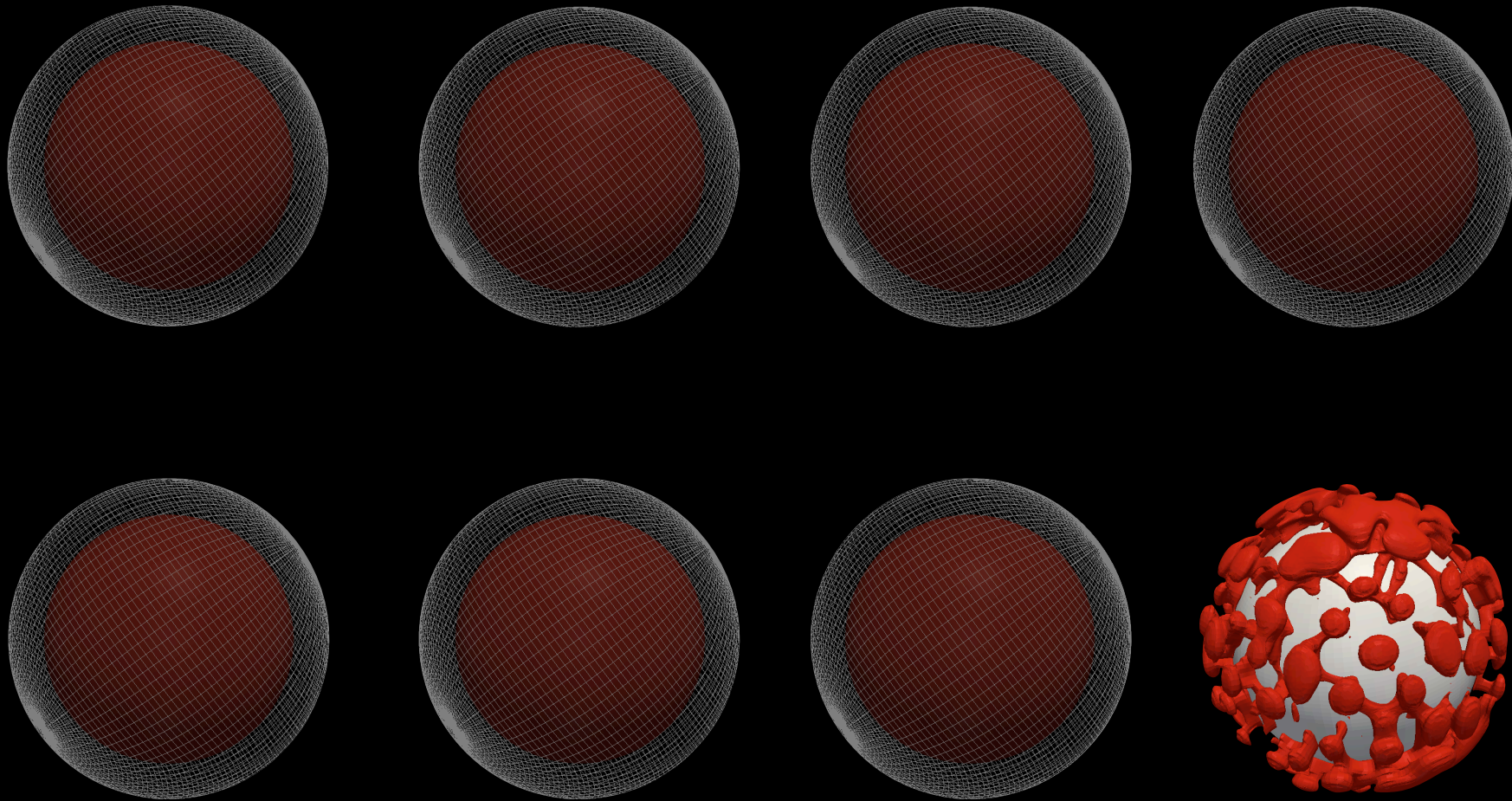


2.0Ga



4.5Ga

HERMEAN MODELS (STATIONARY)



$I = 29$

MANTLE THICKNESS INFLUENCE

TBC

size does matter

OUTLOOK

"SUPER"PLANETS



Moon



*Super-Moon
Super-Mercury*

MAXI- AND MINI-PLANETS

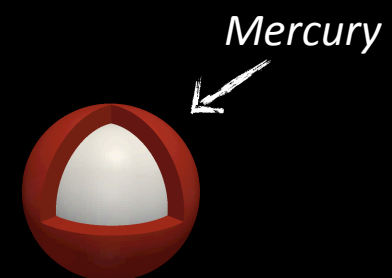
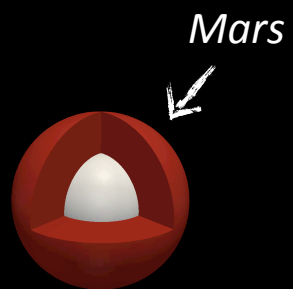
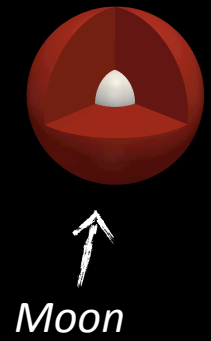


Moon

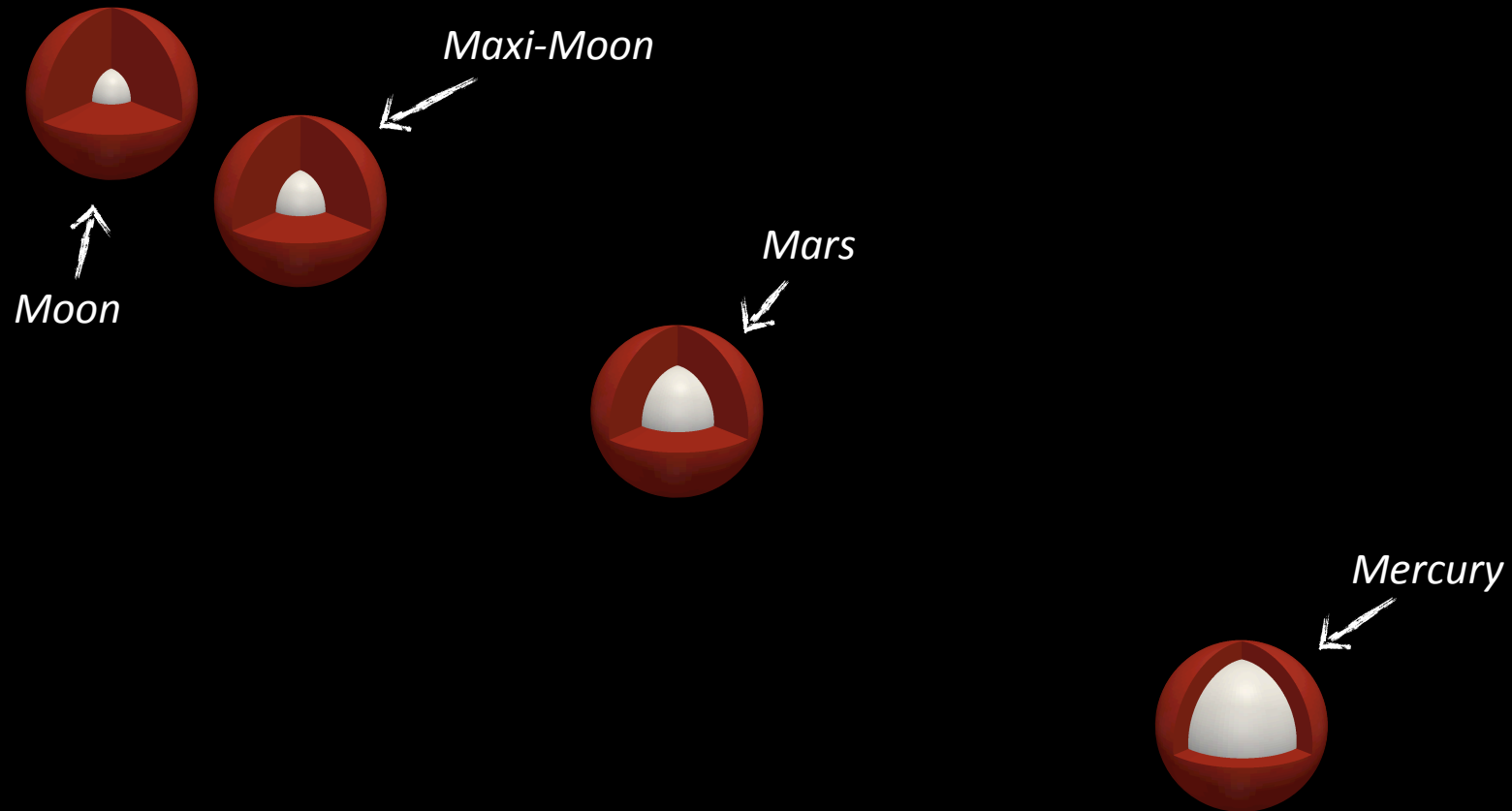


~~*Super-Moon*~~
~~*Super-Mercury*~~
Maxi-Moon
Maxi-Mars
Maxi-Mercury

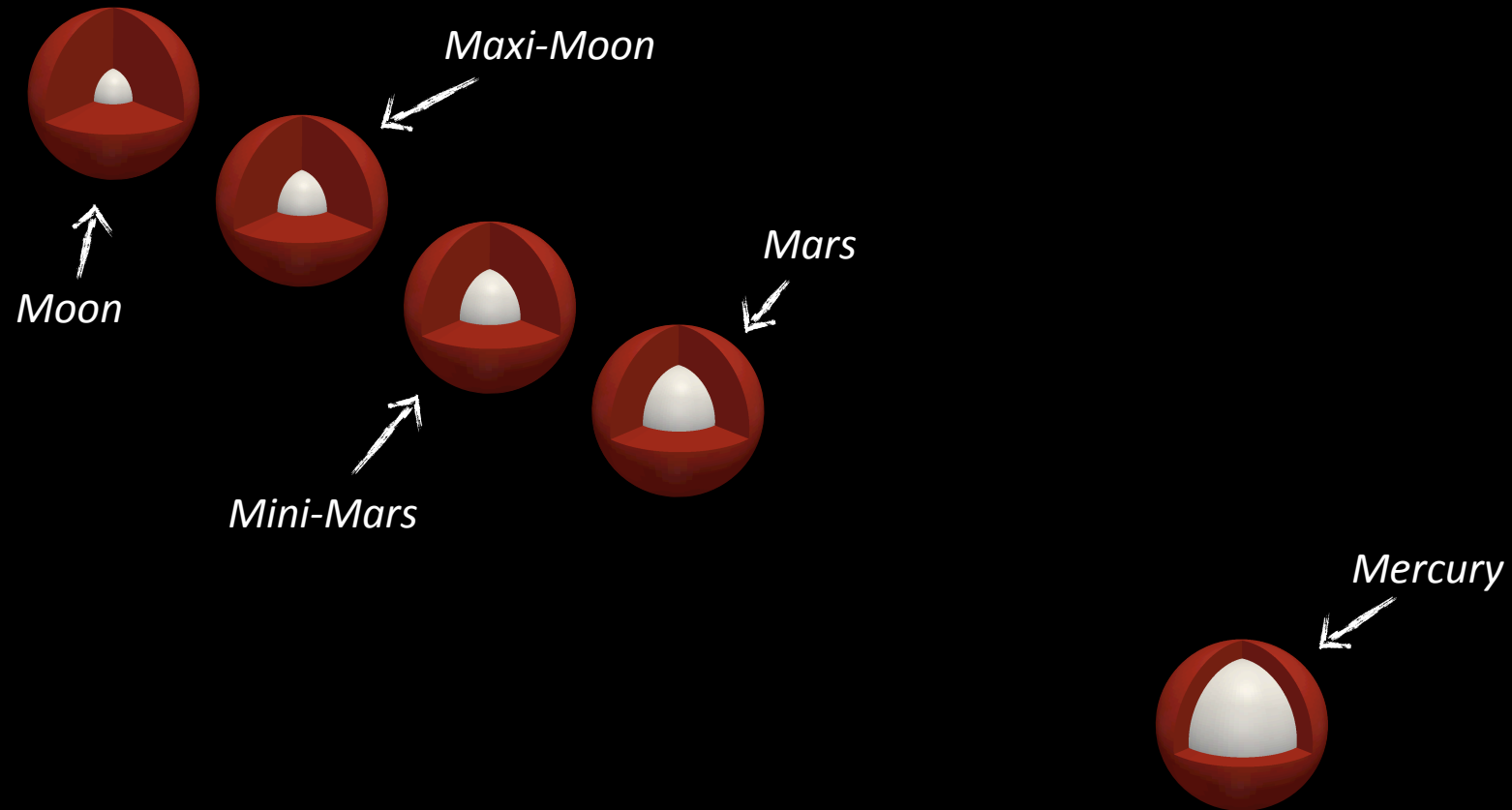
MAXI- AND MINI-PLANETS



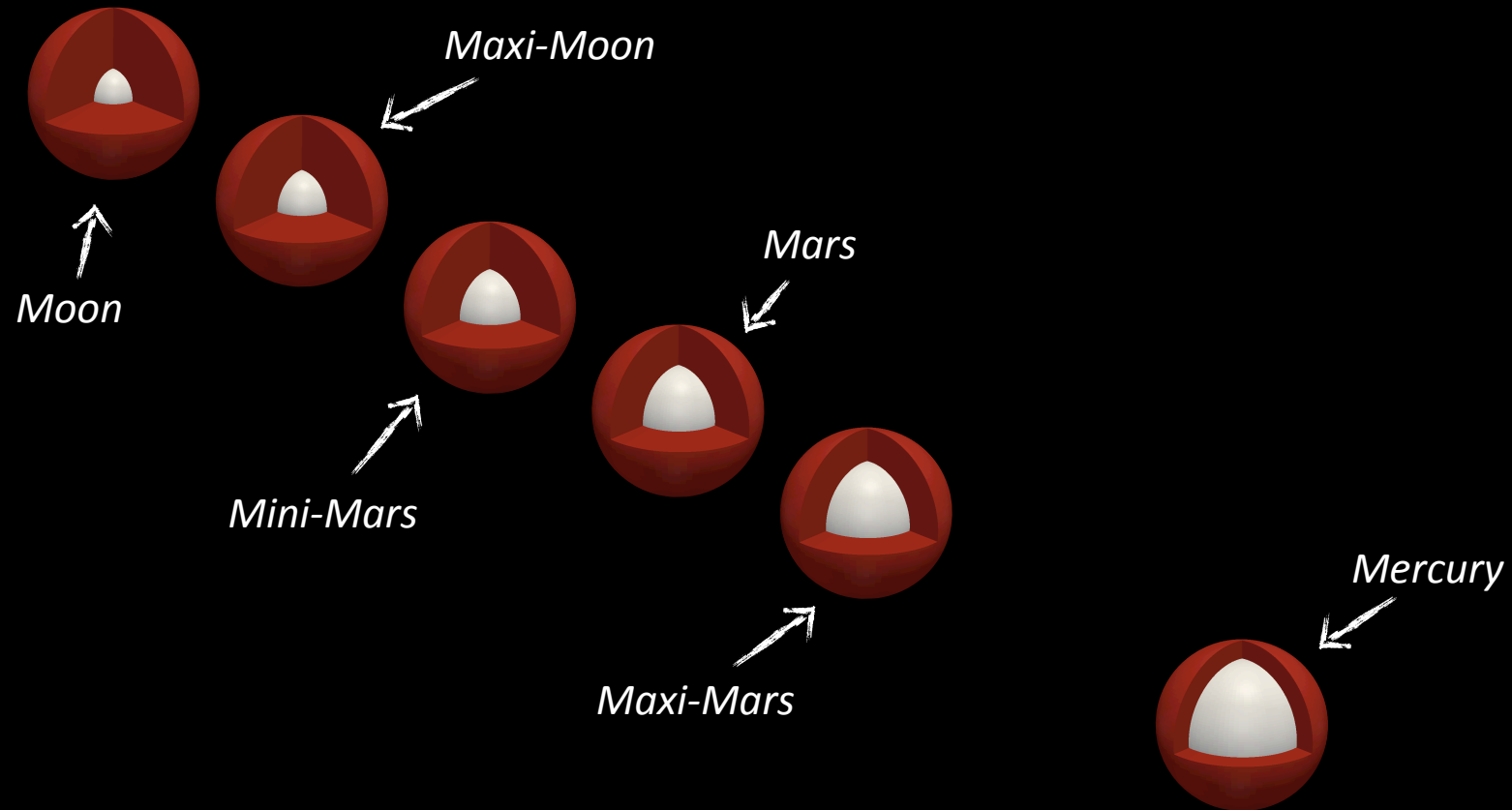
MAXI- AND MINI-PLANETS



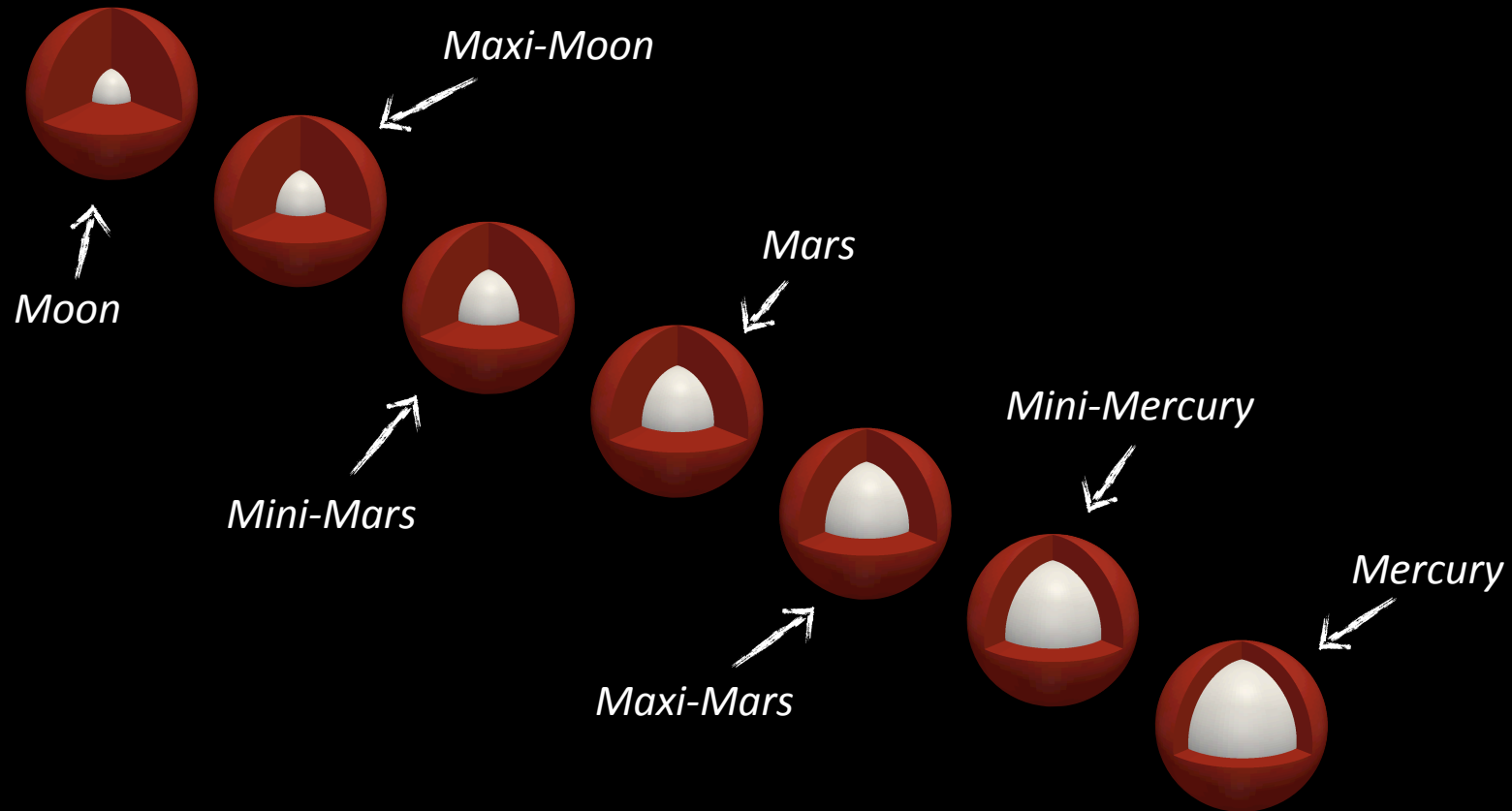
MAXI- AND MINI-PLANETS



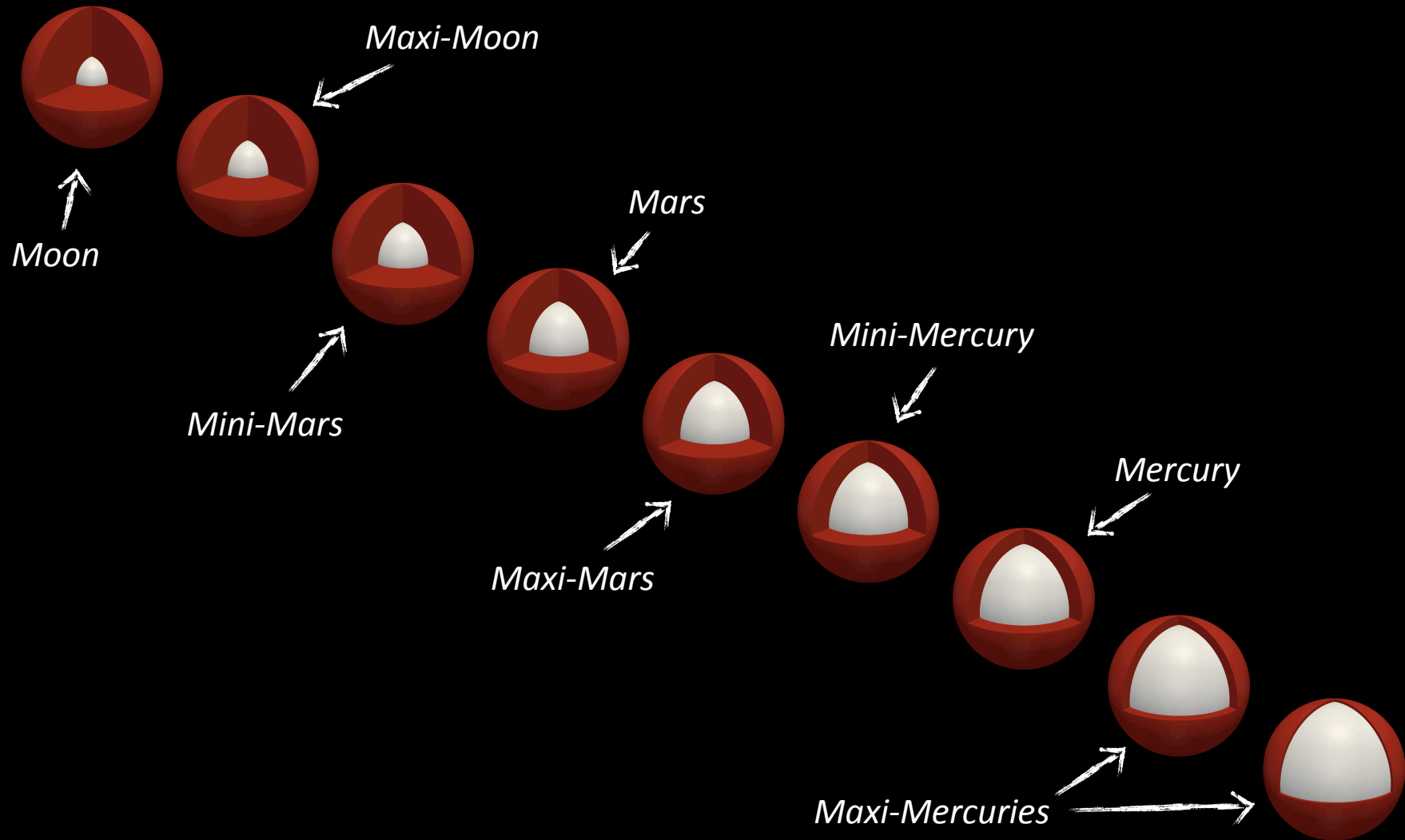
MAXI- AND MINI-PLANETS



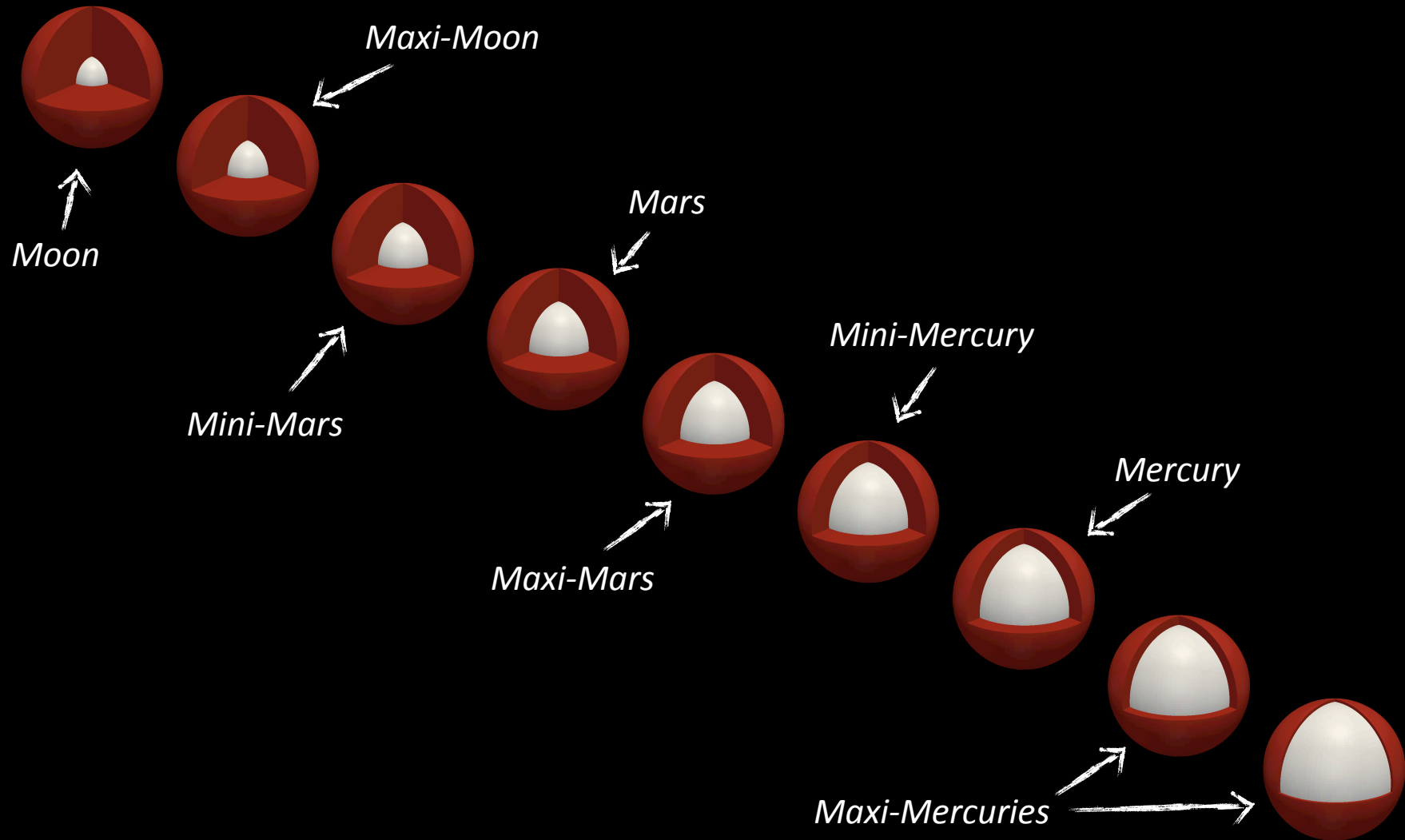
MAXI- AND MINI-PLANETS



MAXI- AND MINI-PLANETS



MAXI- AND MINI-PLANETS



ACKNOWLEDGEMENTS

*G THOERNER
R ZONDAG
R TURNER
J STUEWE
B KAUS*

