

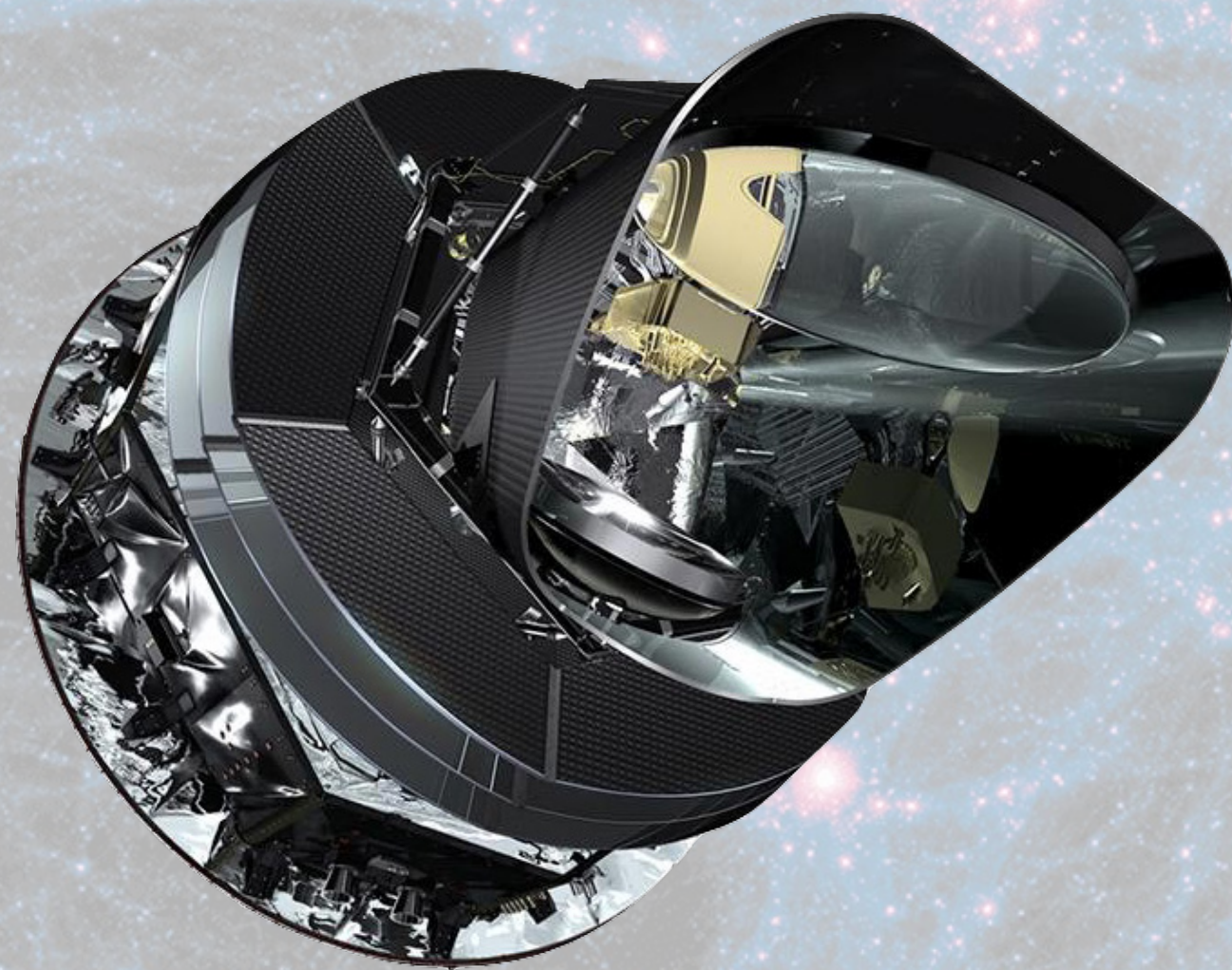
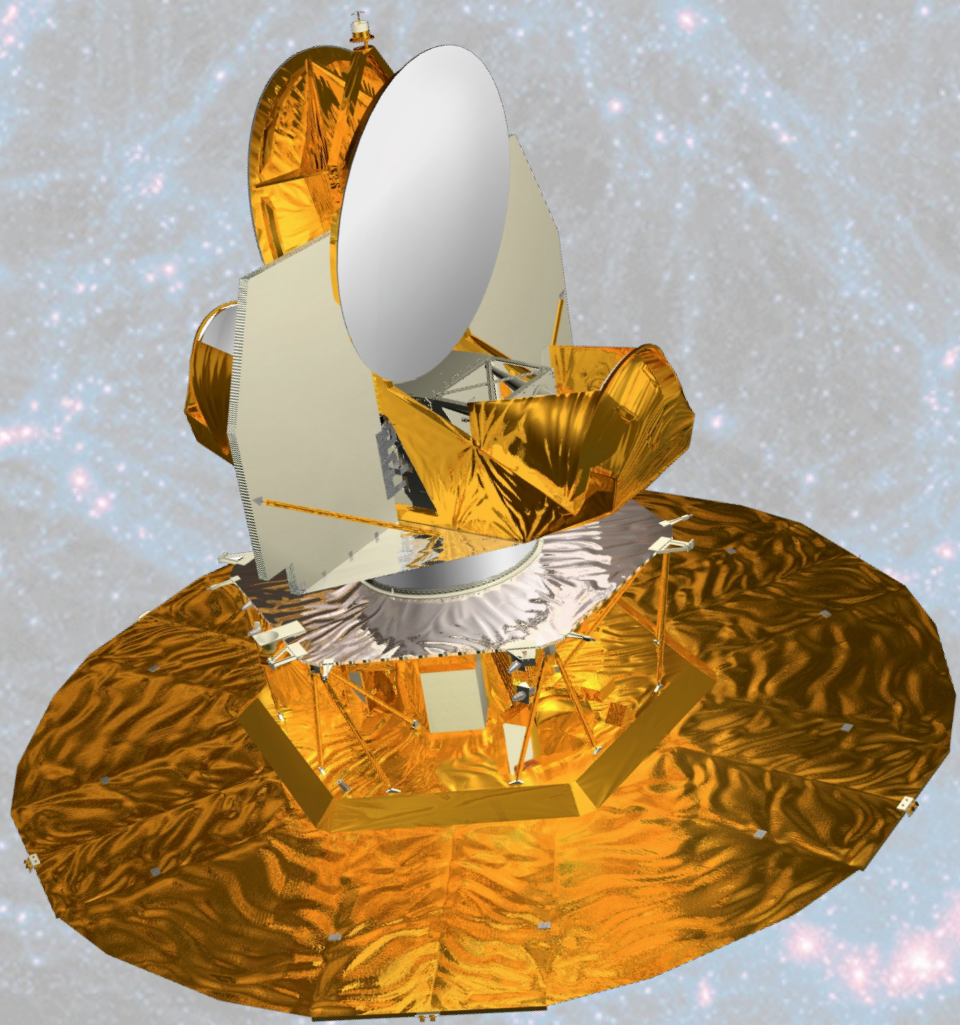


Constraining the shape of the Universe using Circle Searches

PASCOS 2025
Durham University
July 24 2025

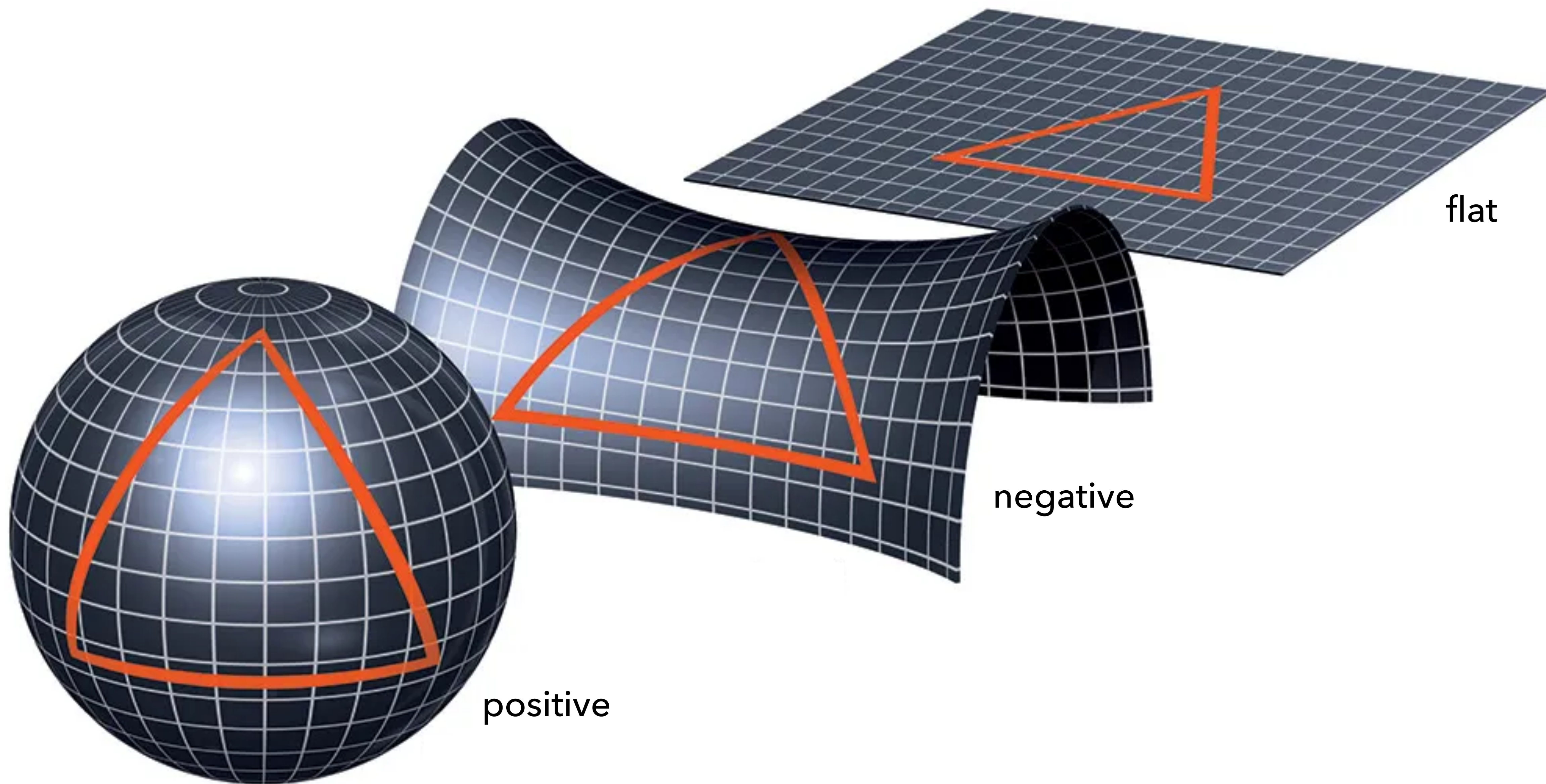
Deyan MIHAYLOV
Case Western Reserve University
COMPACT Collaboration

What is cosmic topology and why study it?

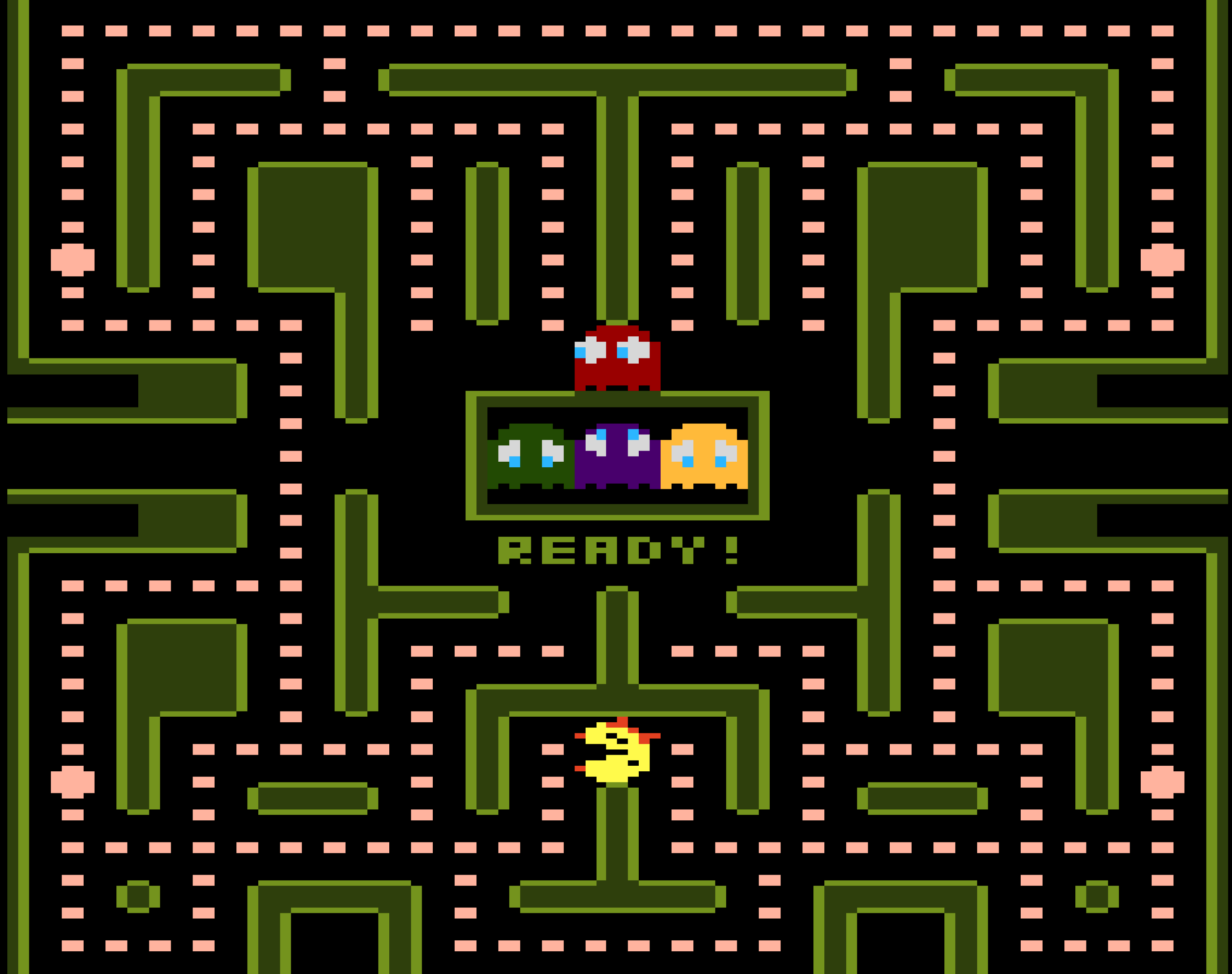


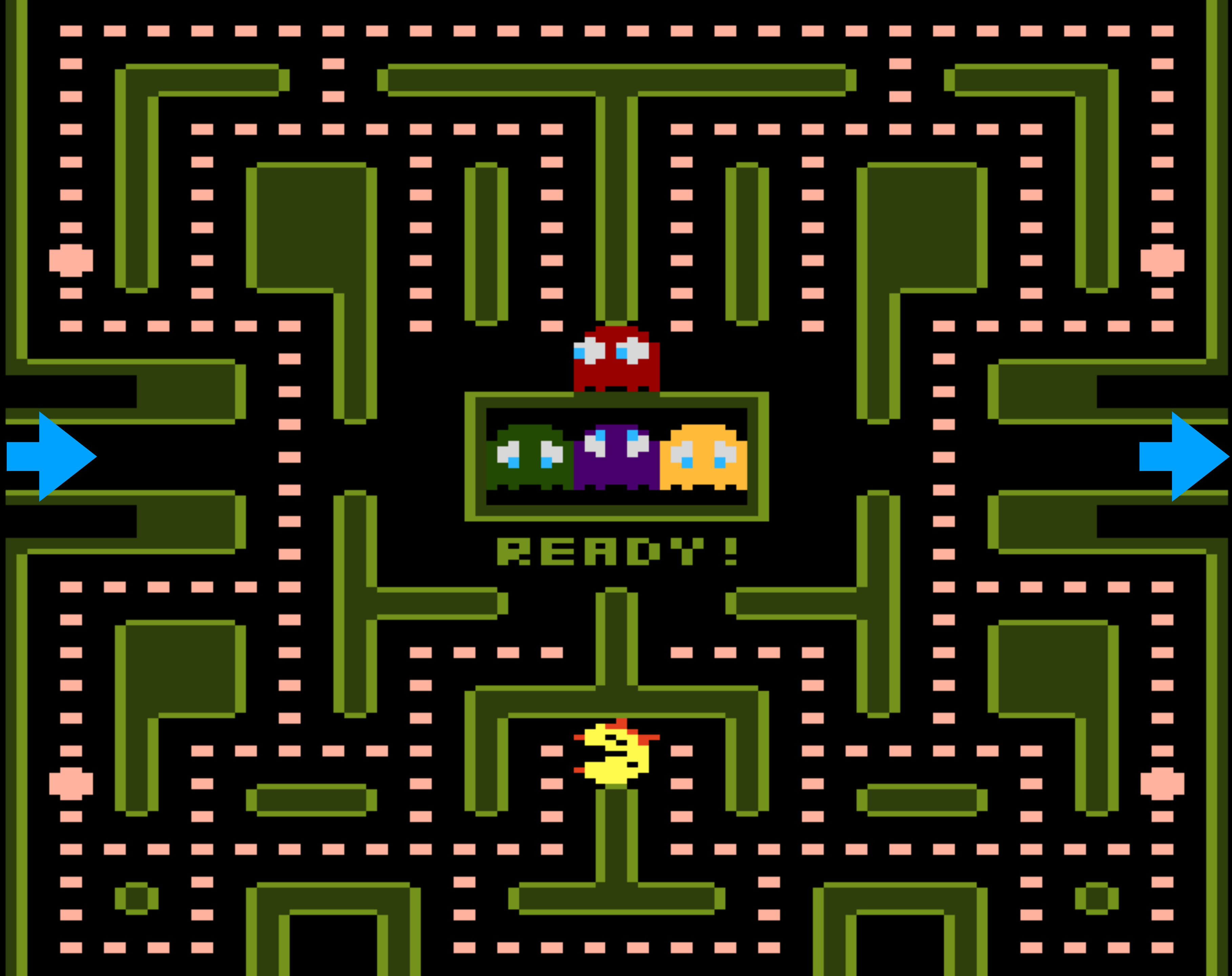
The background of the image is filled with numerous white, 3D-printed mathematical objects. These objects represent various topological surfaces and shapes. Some are simple, like a sphere or a torus (donut shape). Others are more complex, featuring multiple holes or connected components. For example, there are shapes that look like a sphere with a hole, a torus with a smaller hole, and some that are connected to each other in various ways. The objects are scattered across the frame, creating a dense field of geometric forms. The text "Wait, topology?!" is centered over this field.

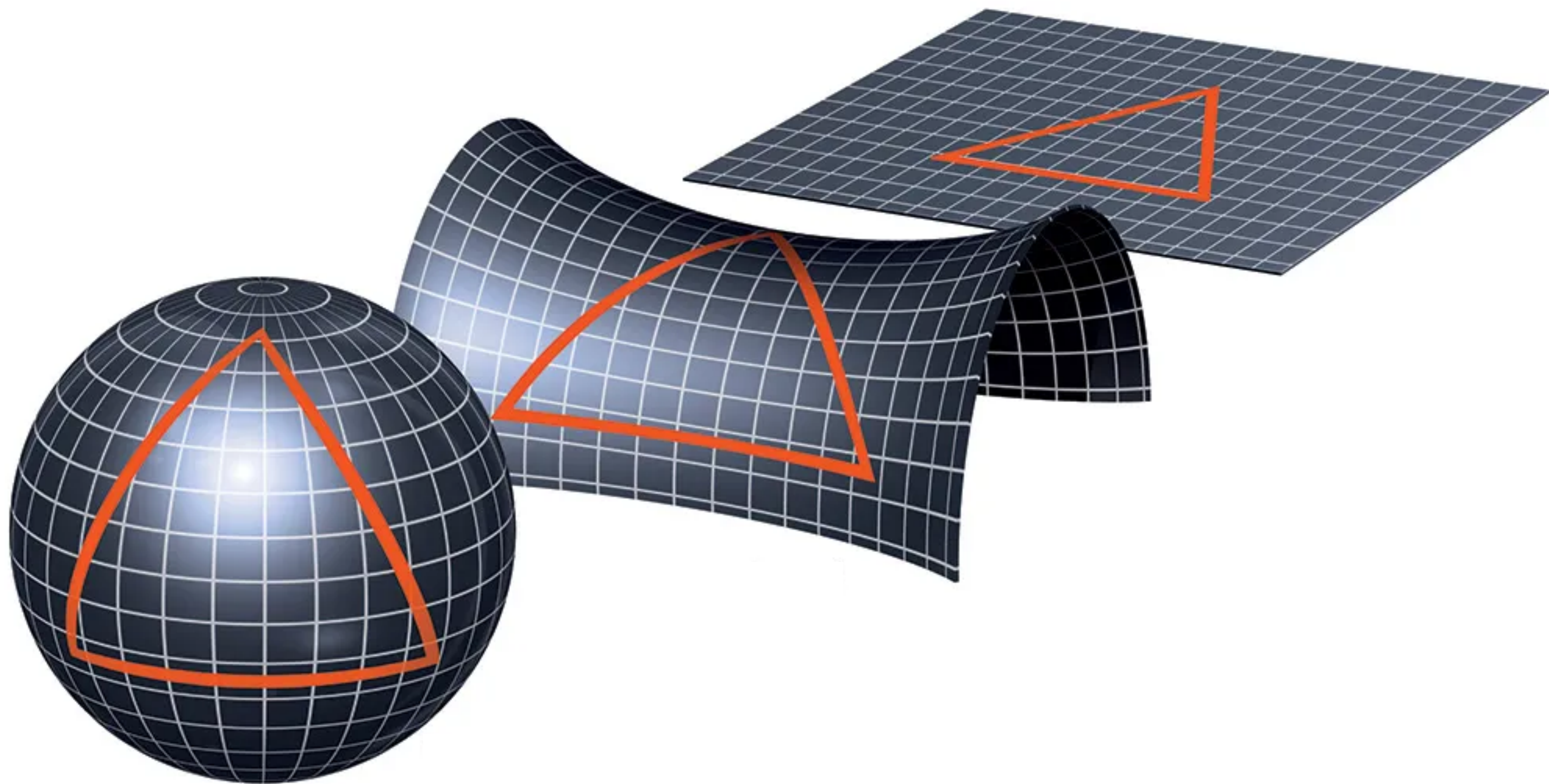
Wait, topology?!

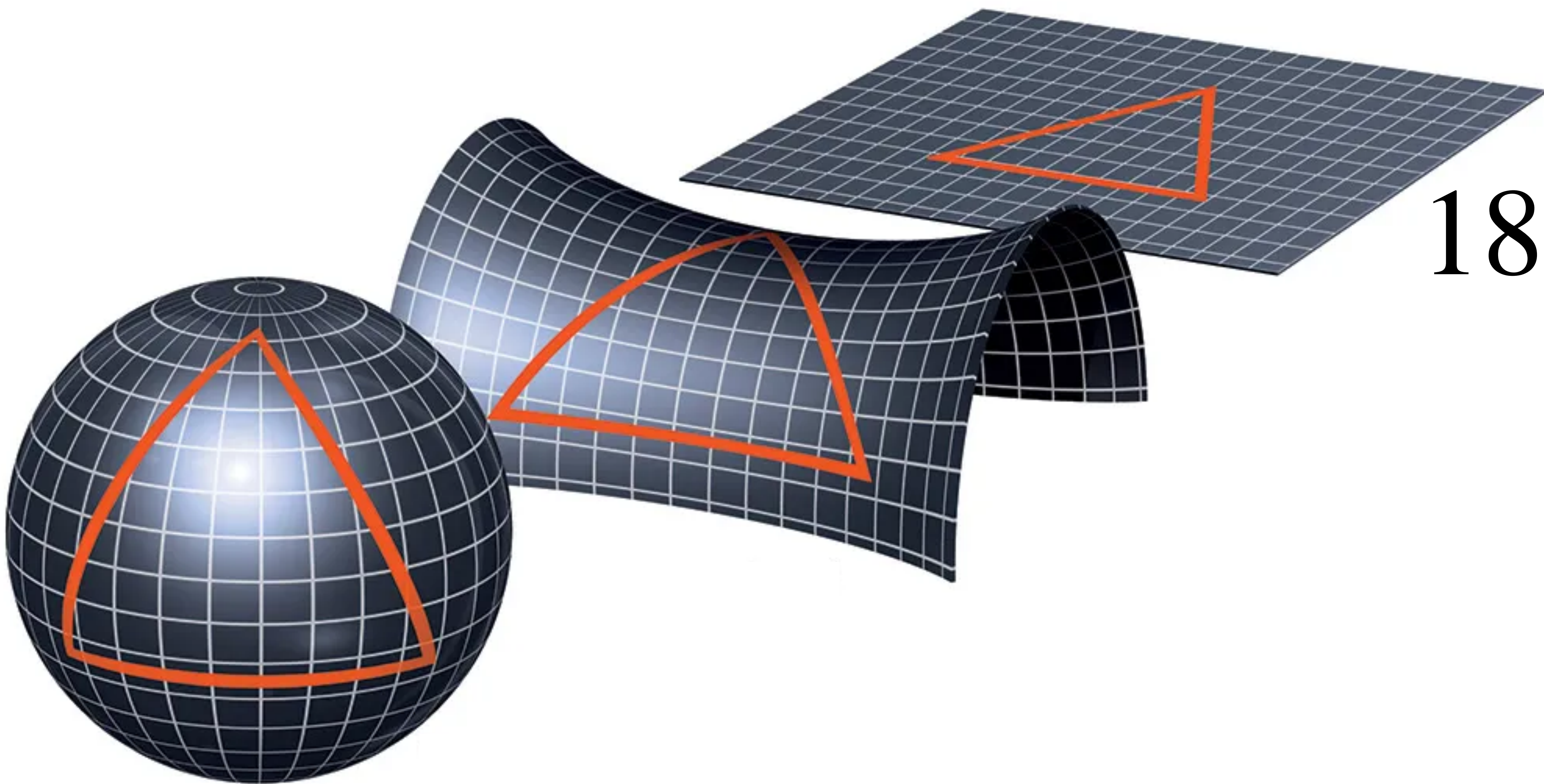




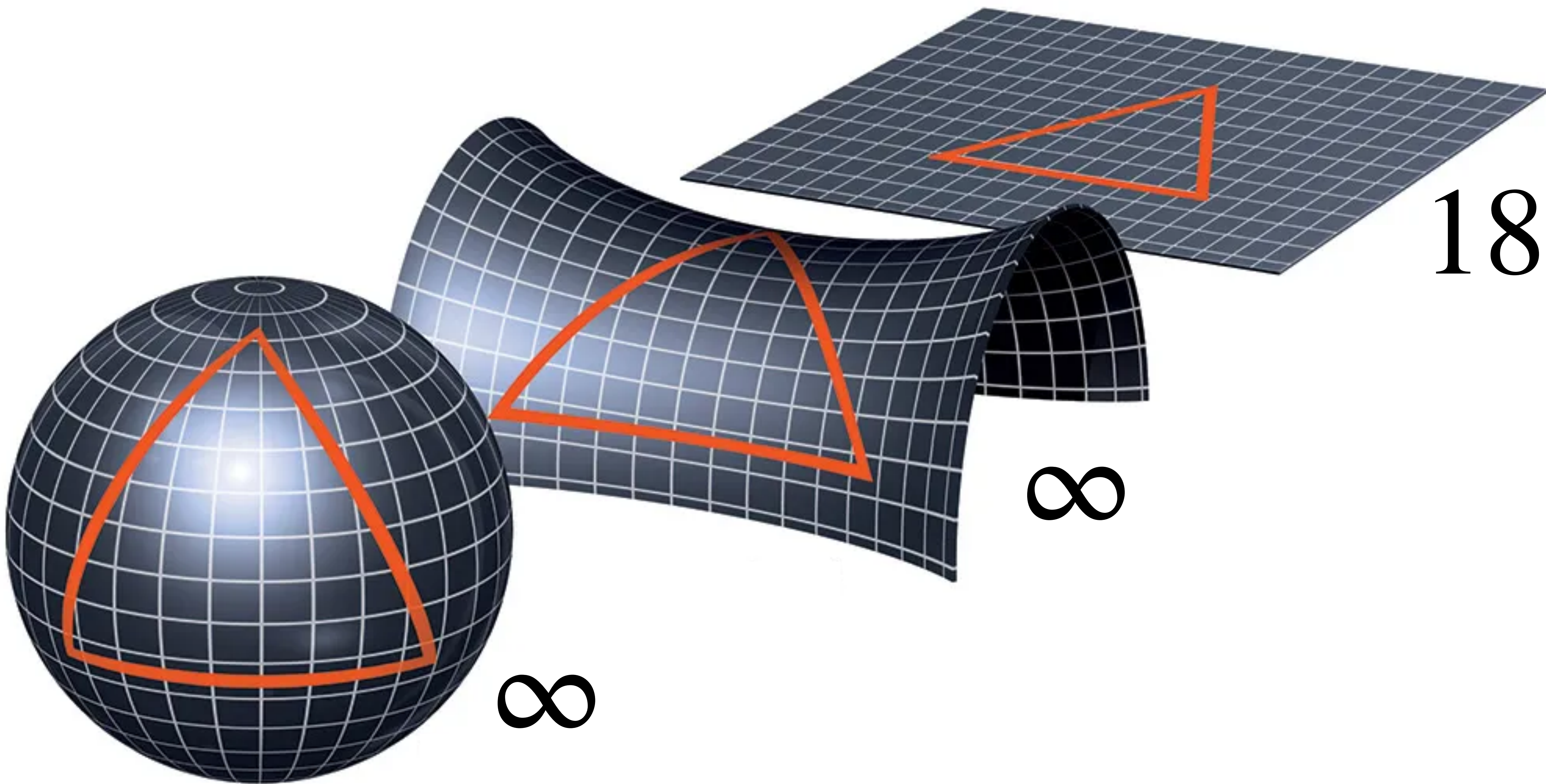


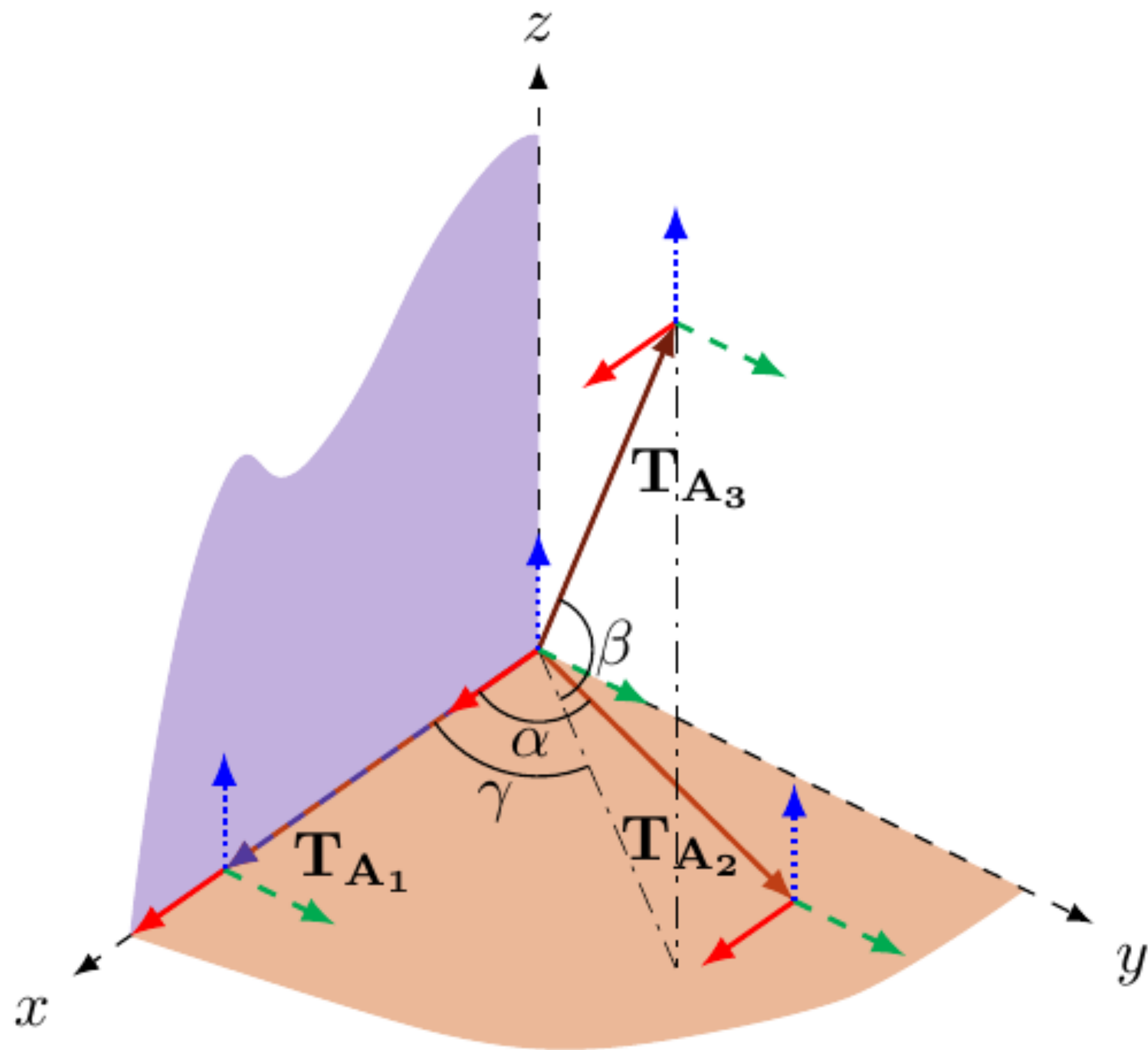




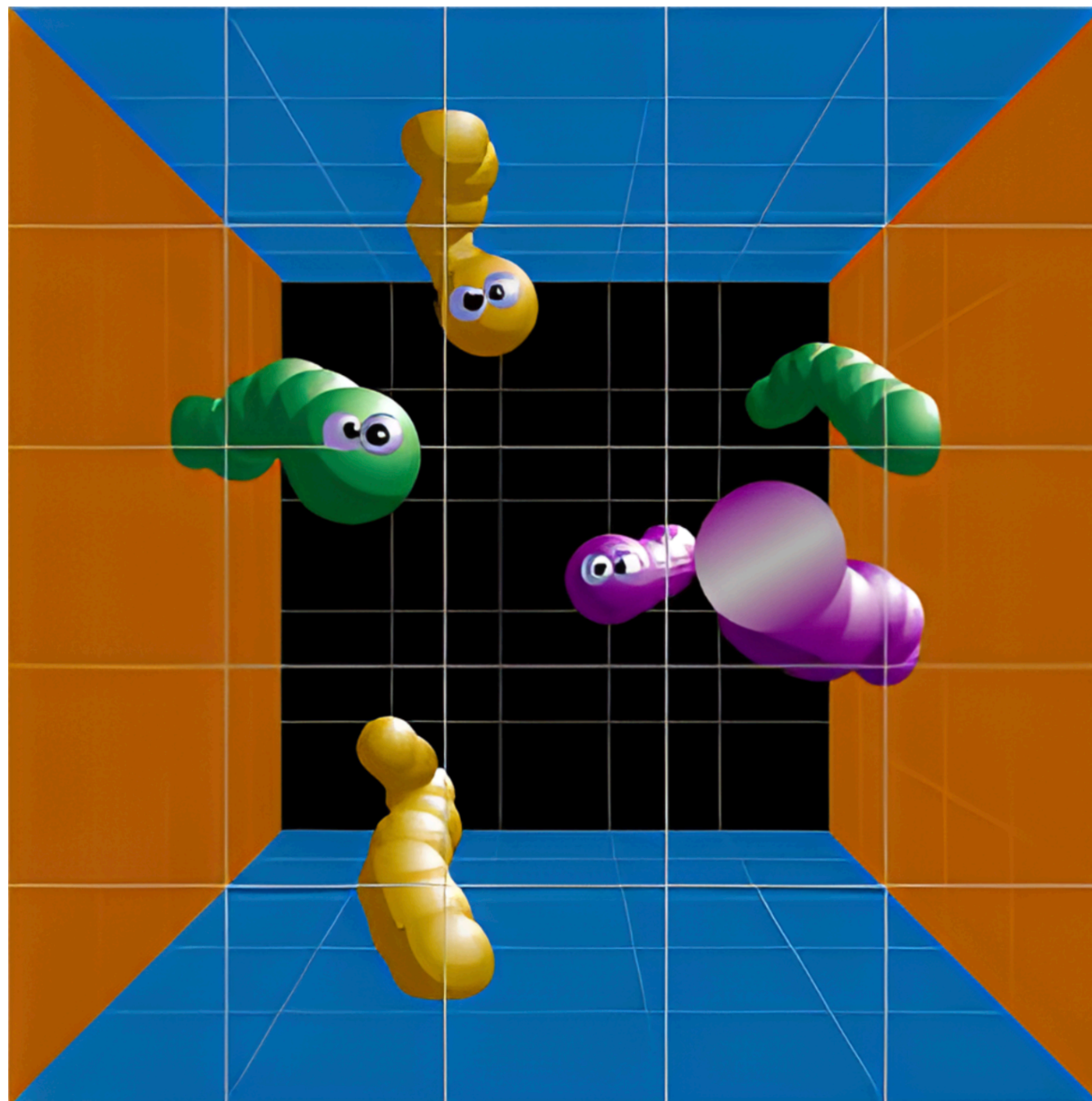


18

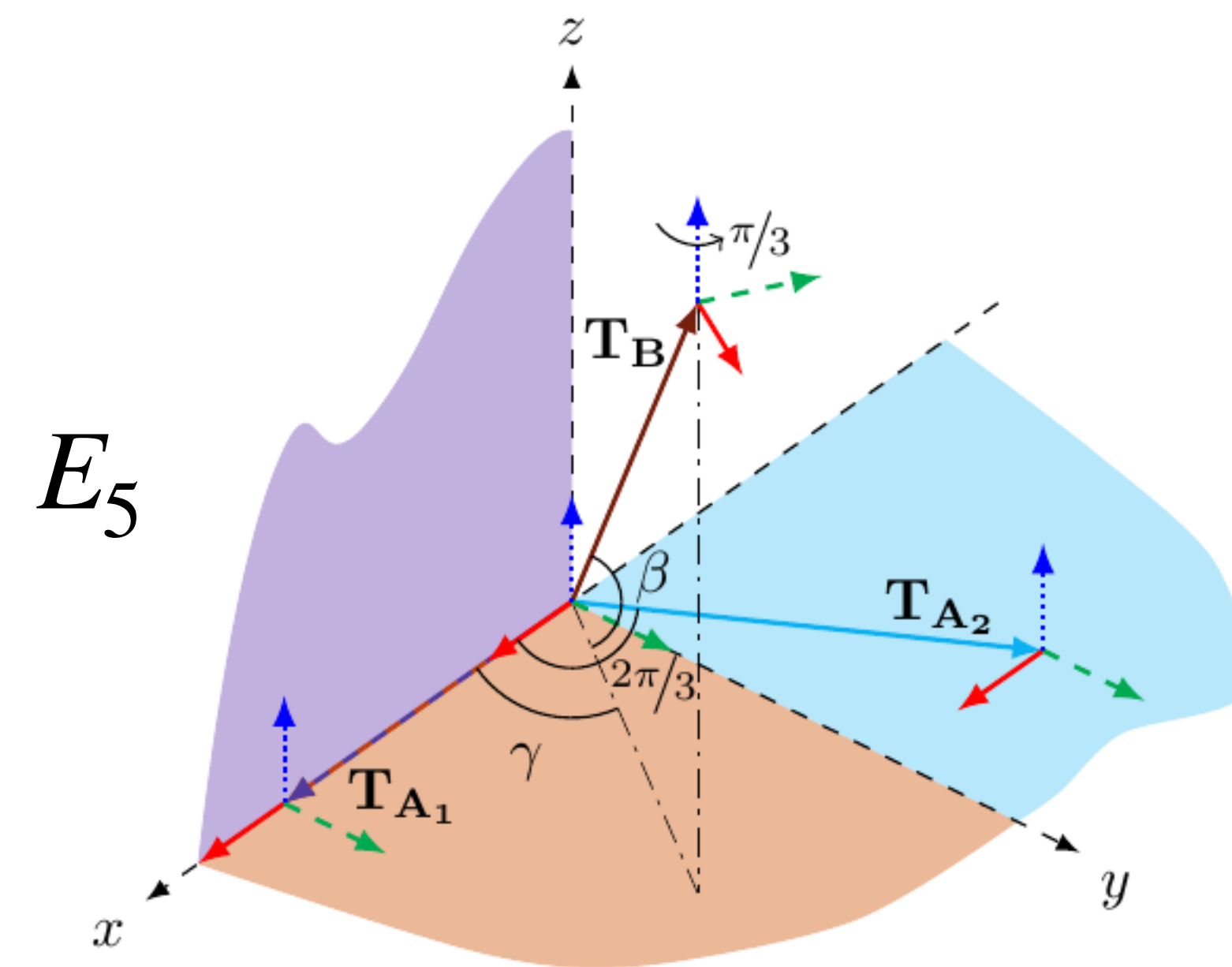
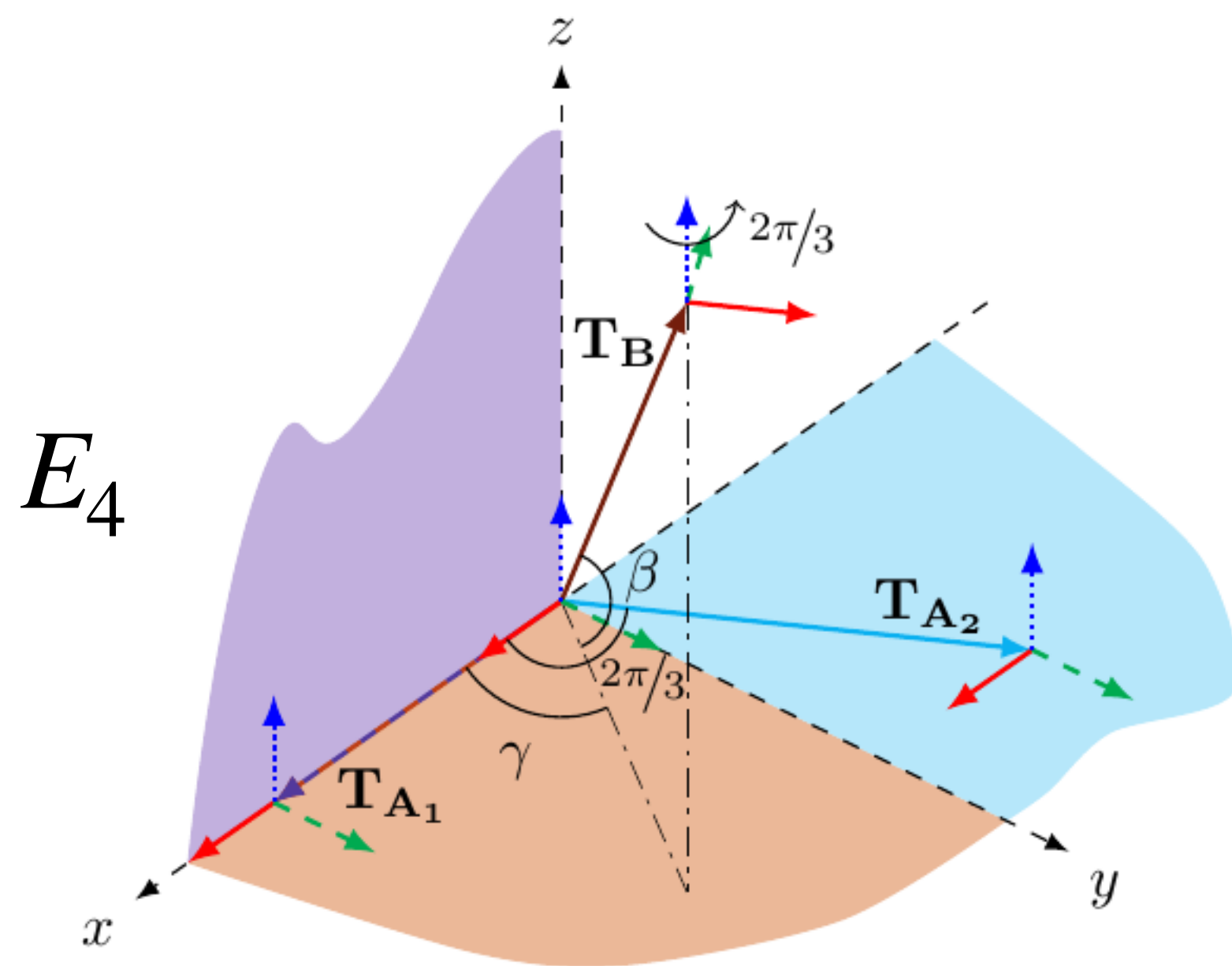
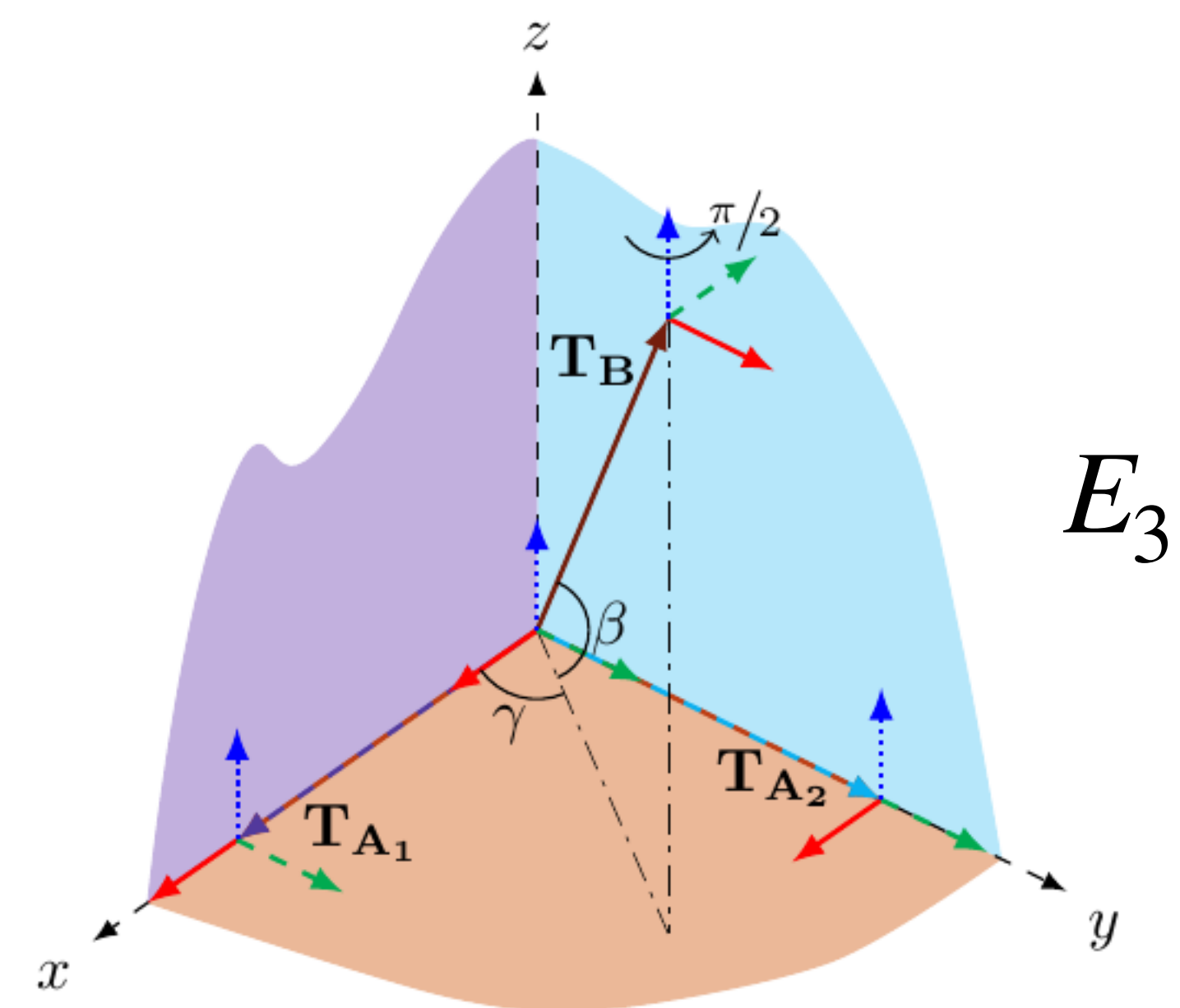
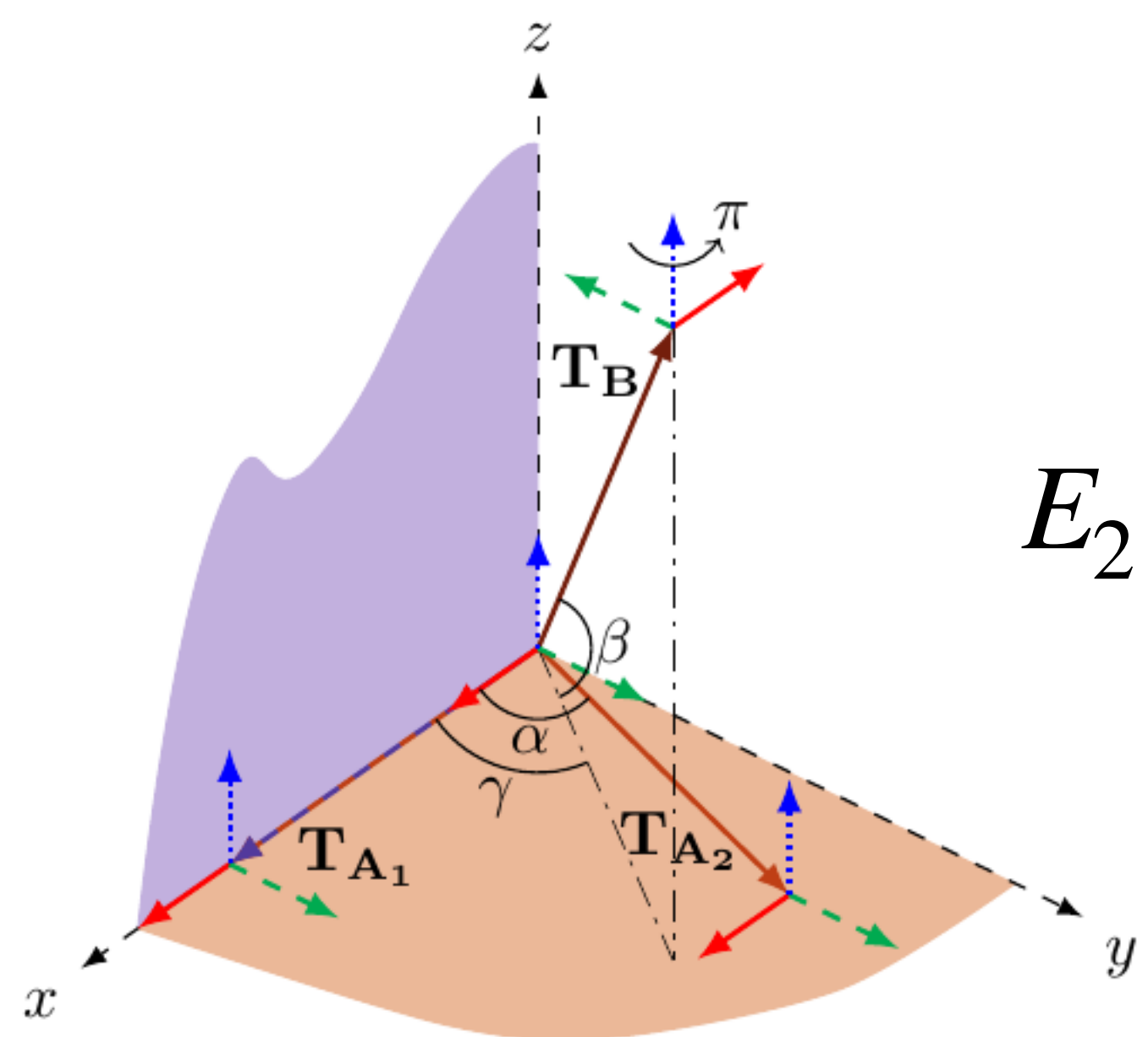


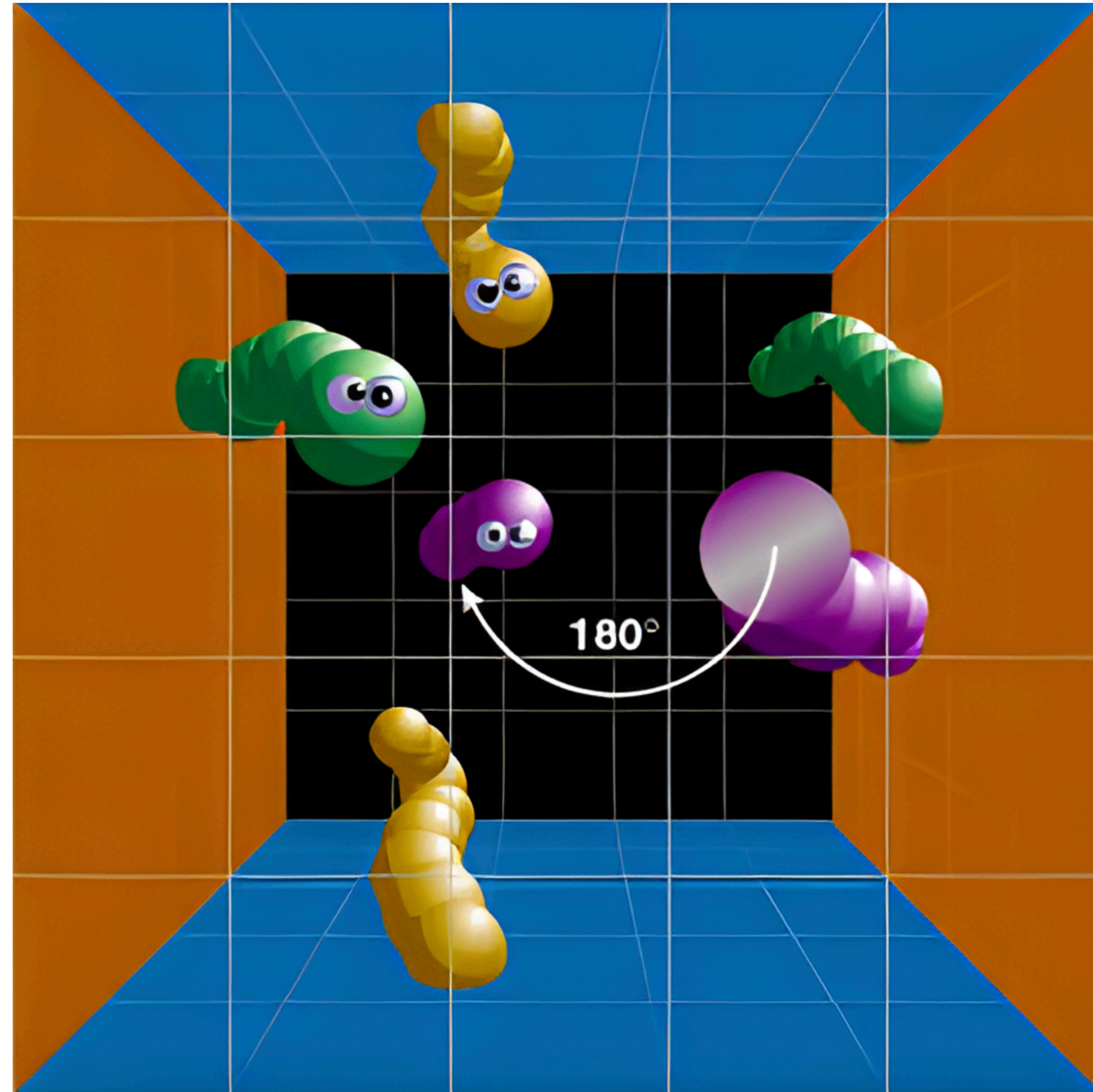


E_1



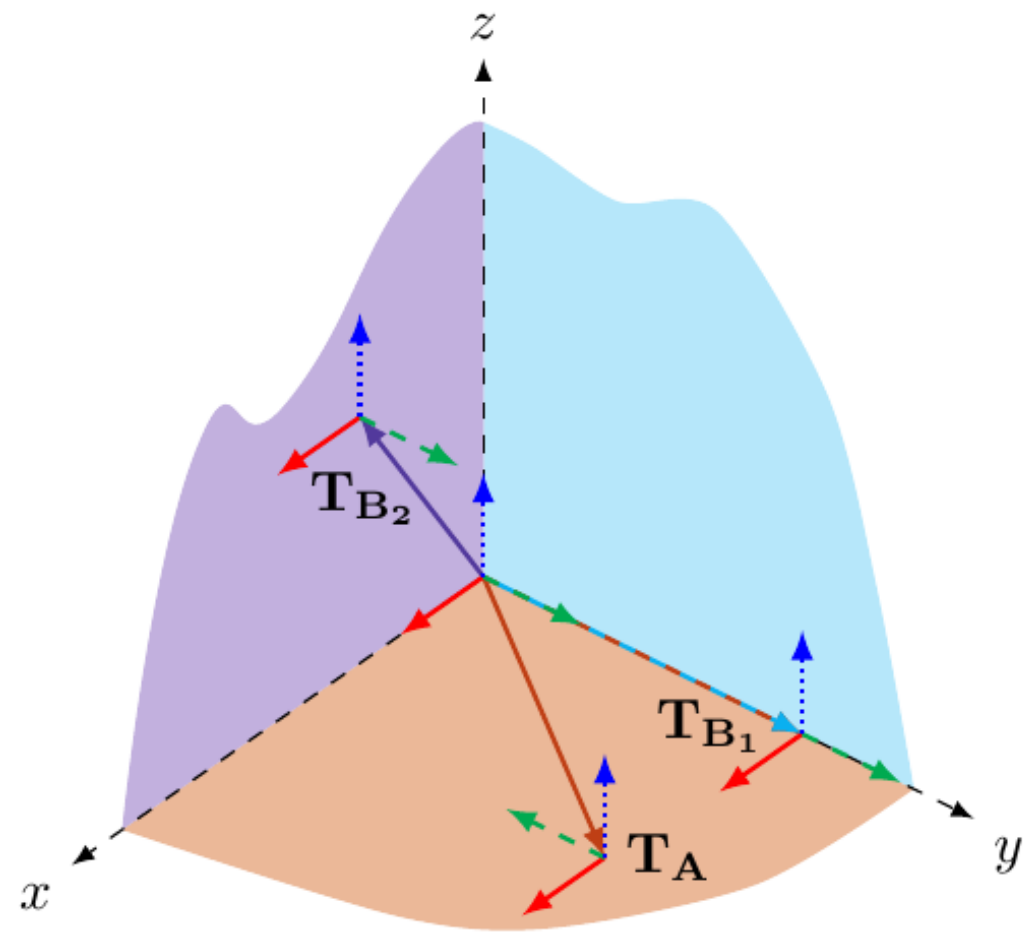
E_1



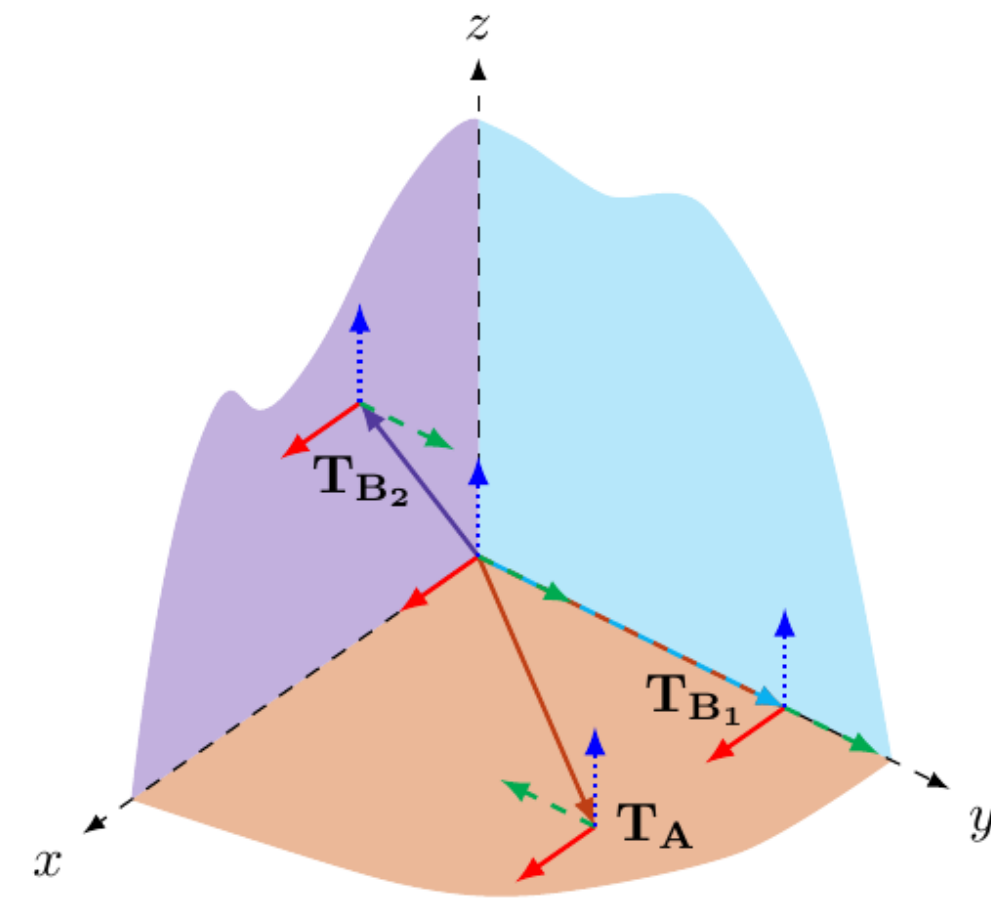


E_2

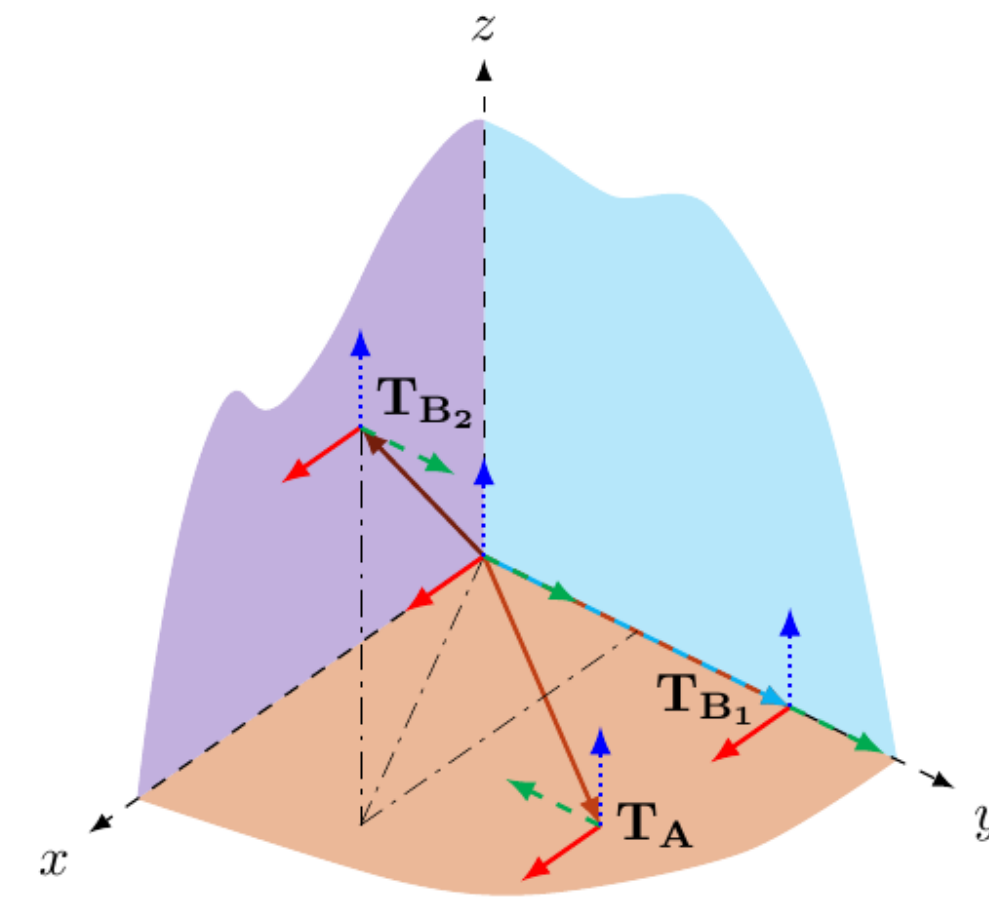
Klein topologies



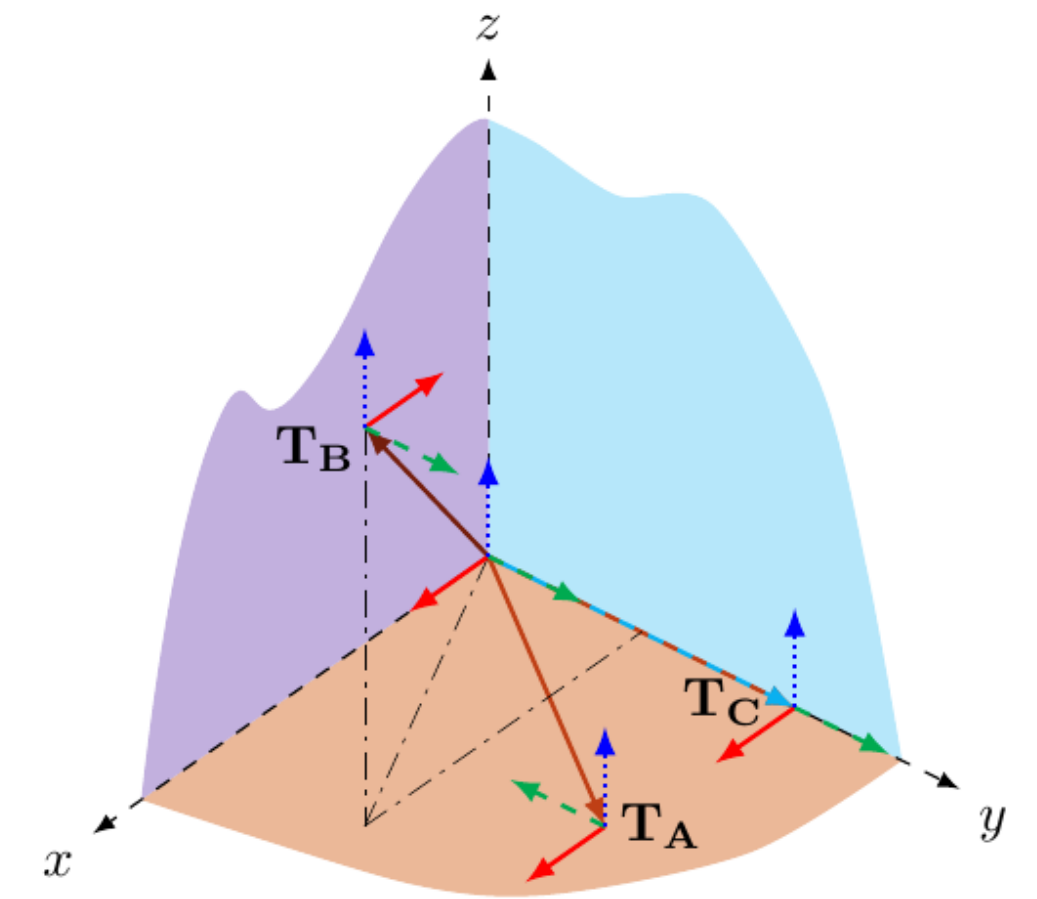
E_7



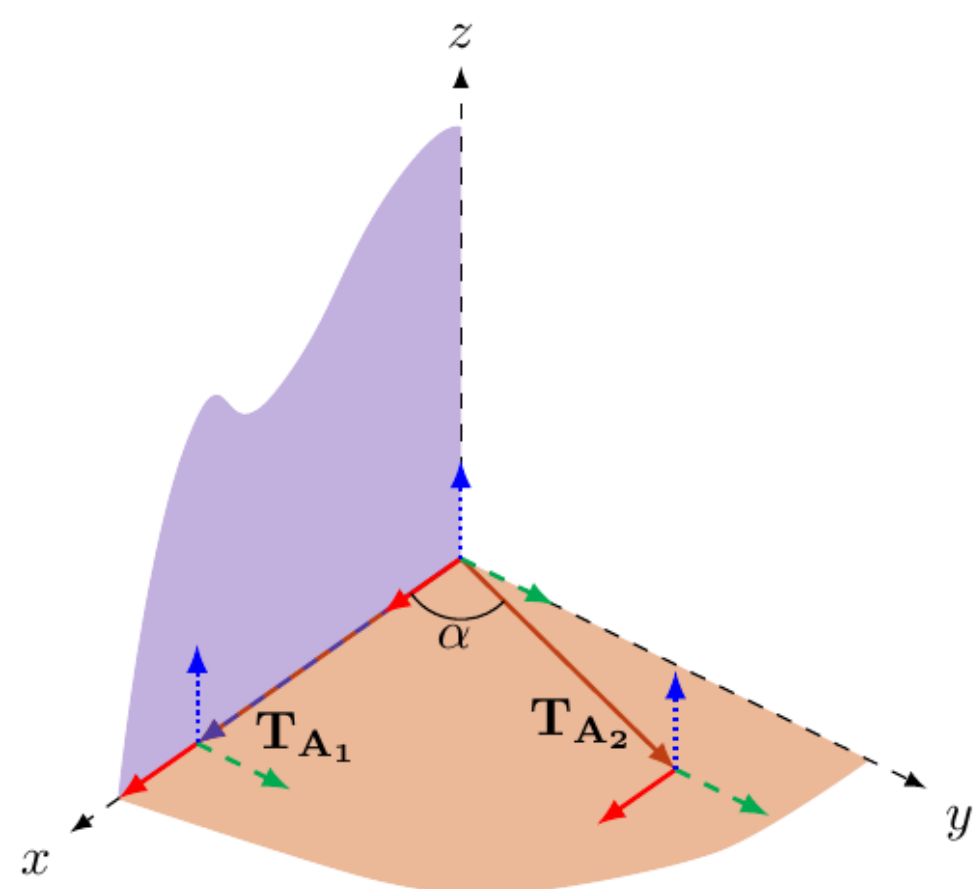
E_8



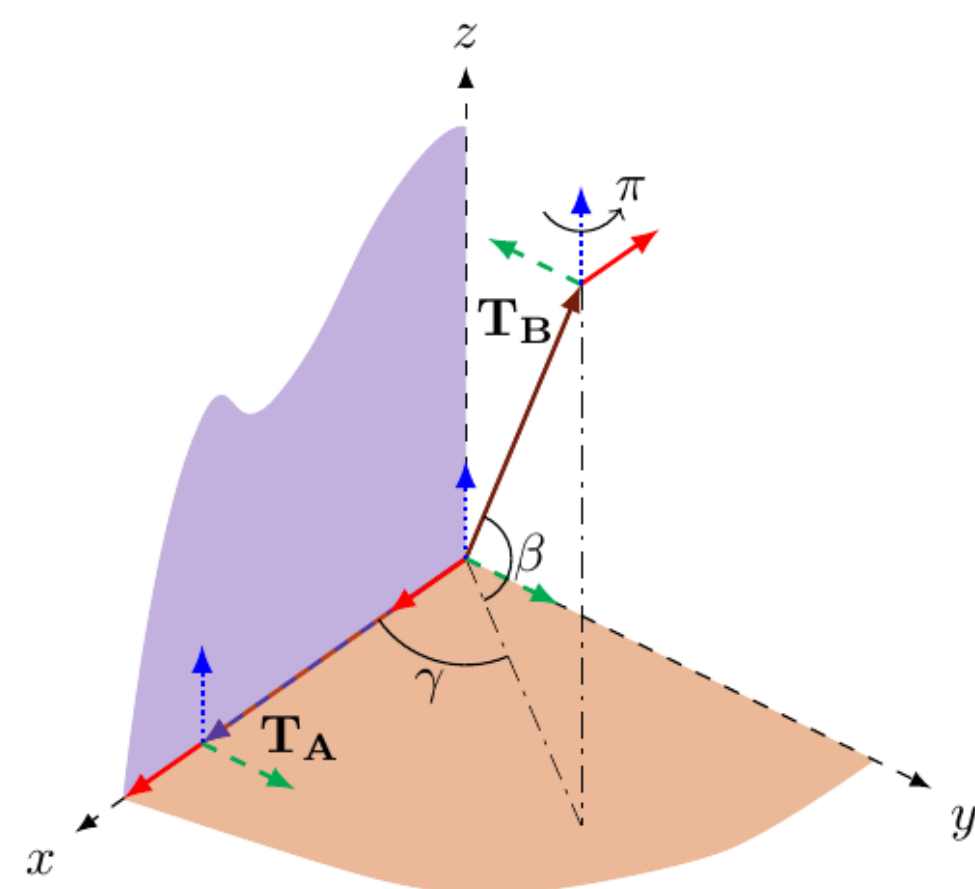
E_9



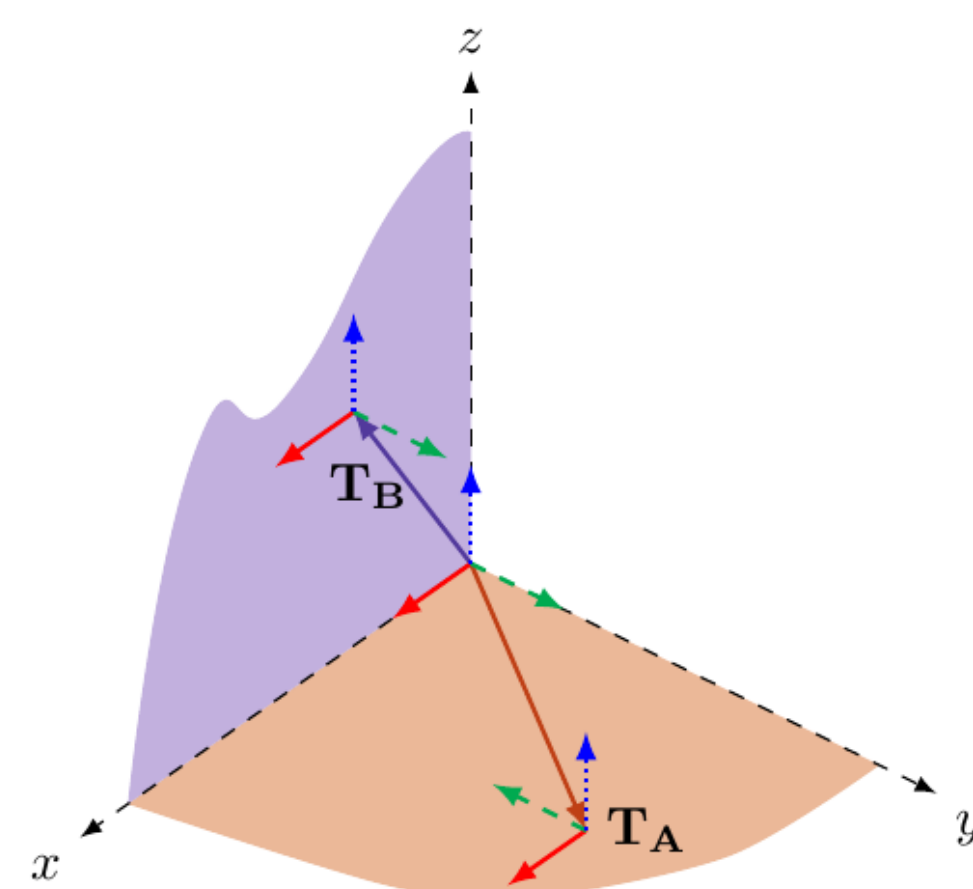
E_{10}



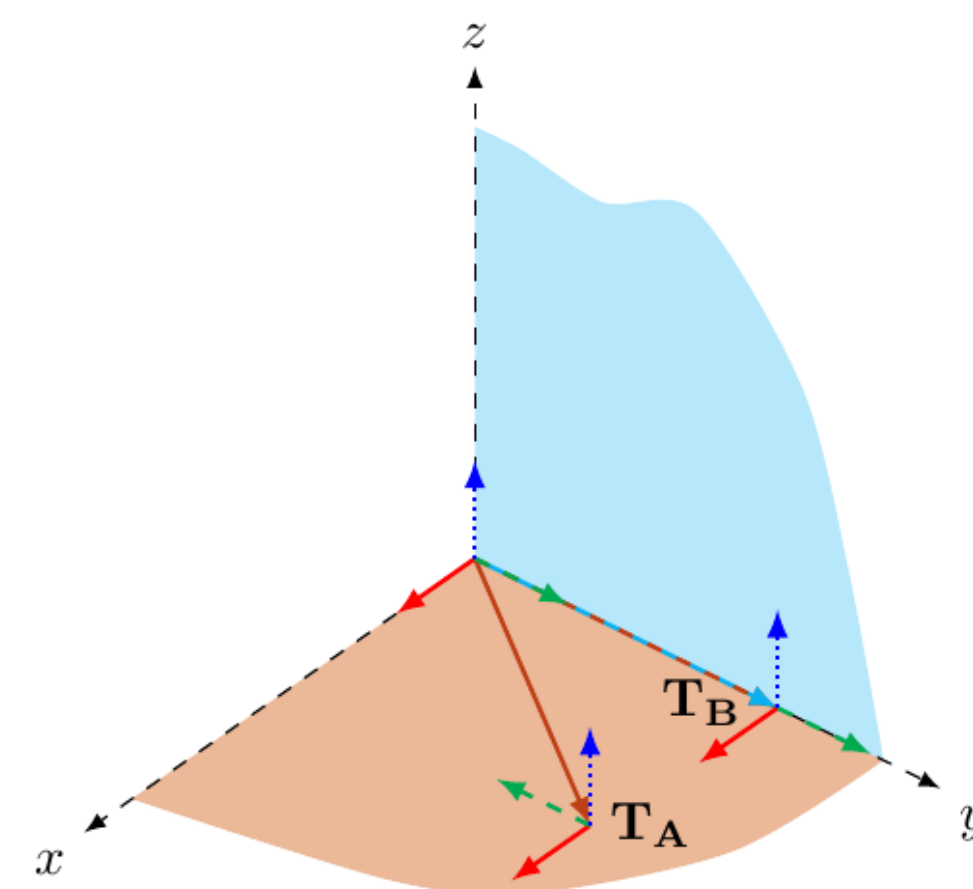
E_{11}



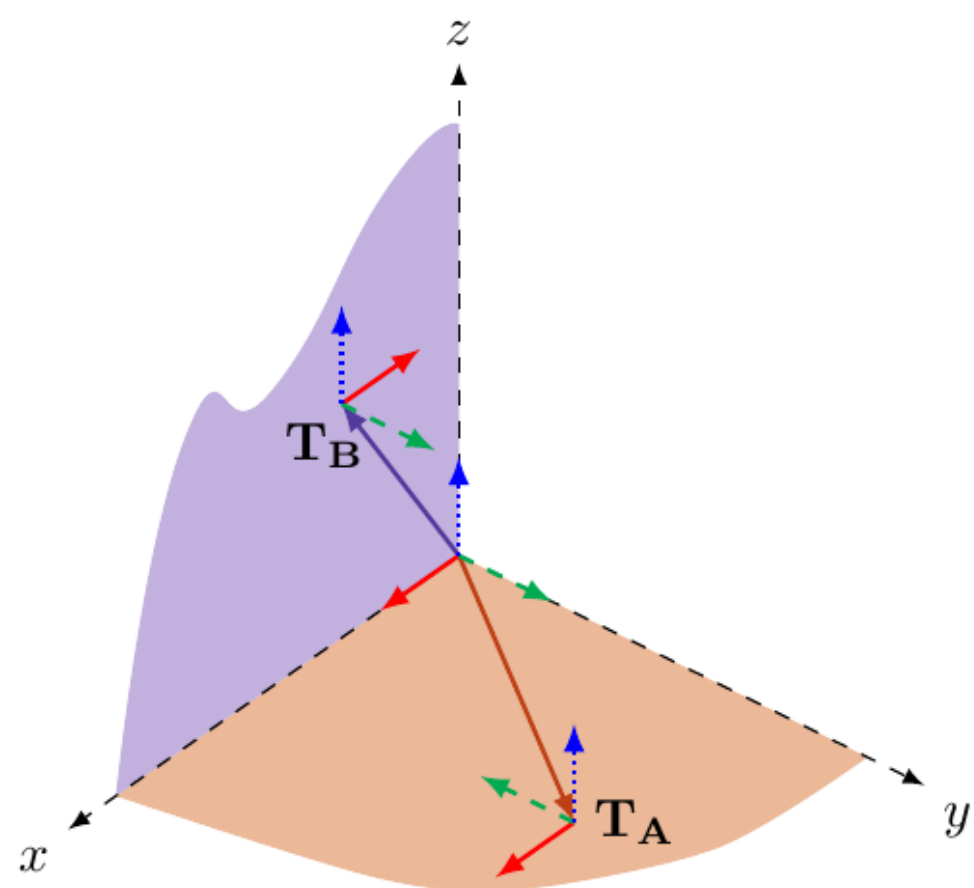
E_{12}



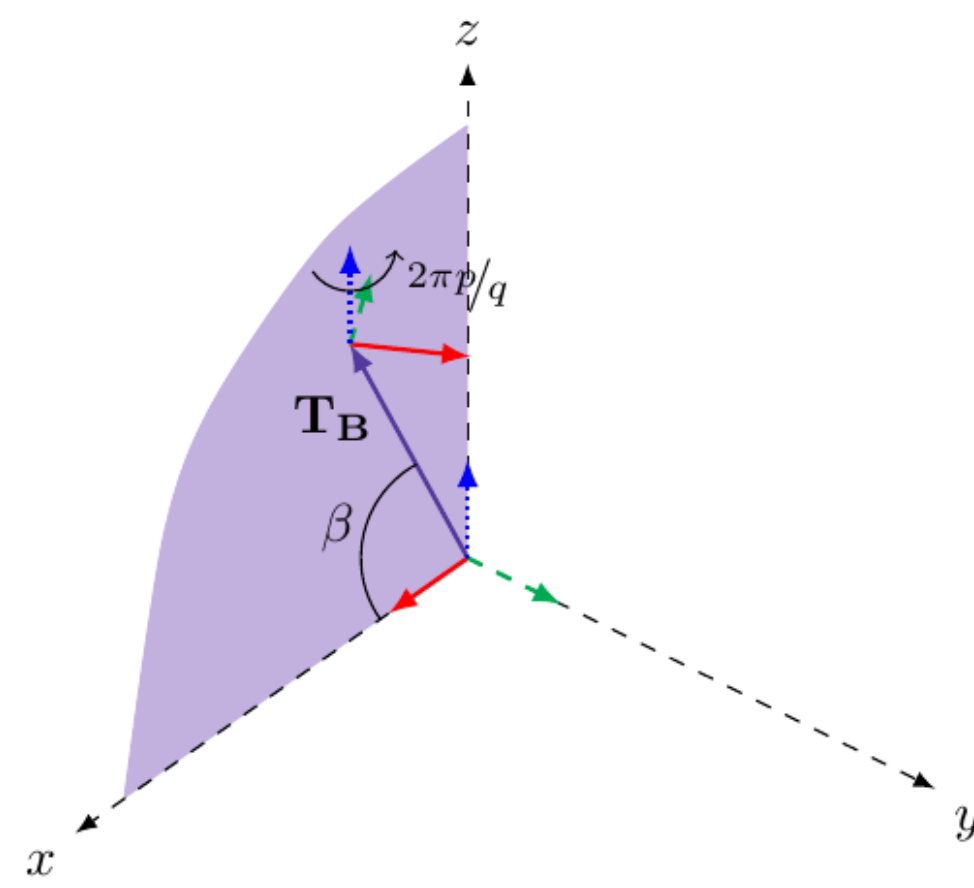
E_{13}



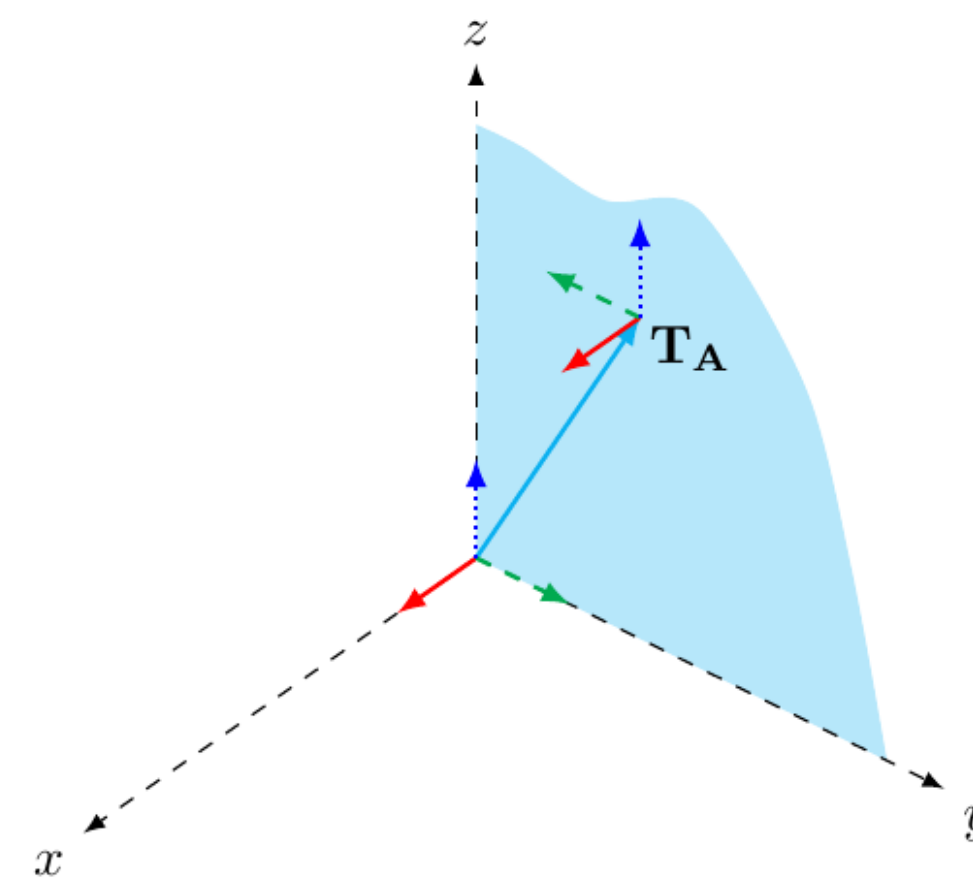
E_{14}



E_{15}

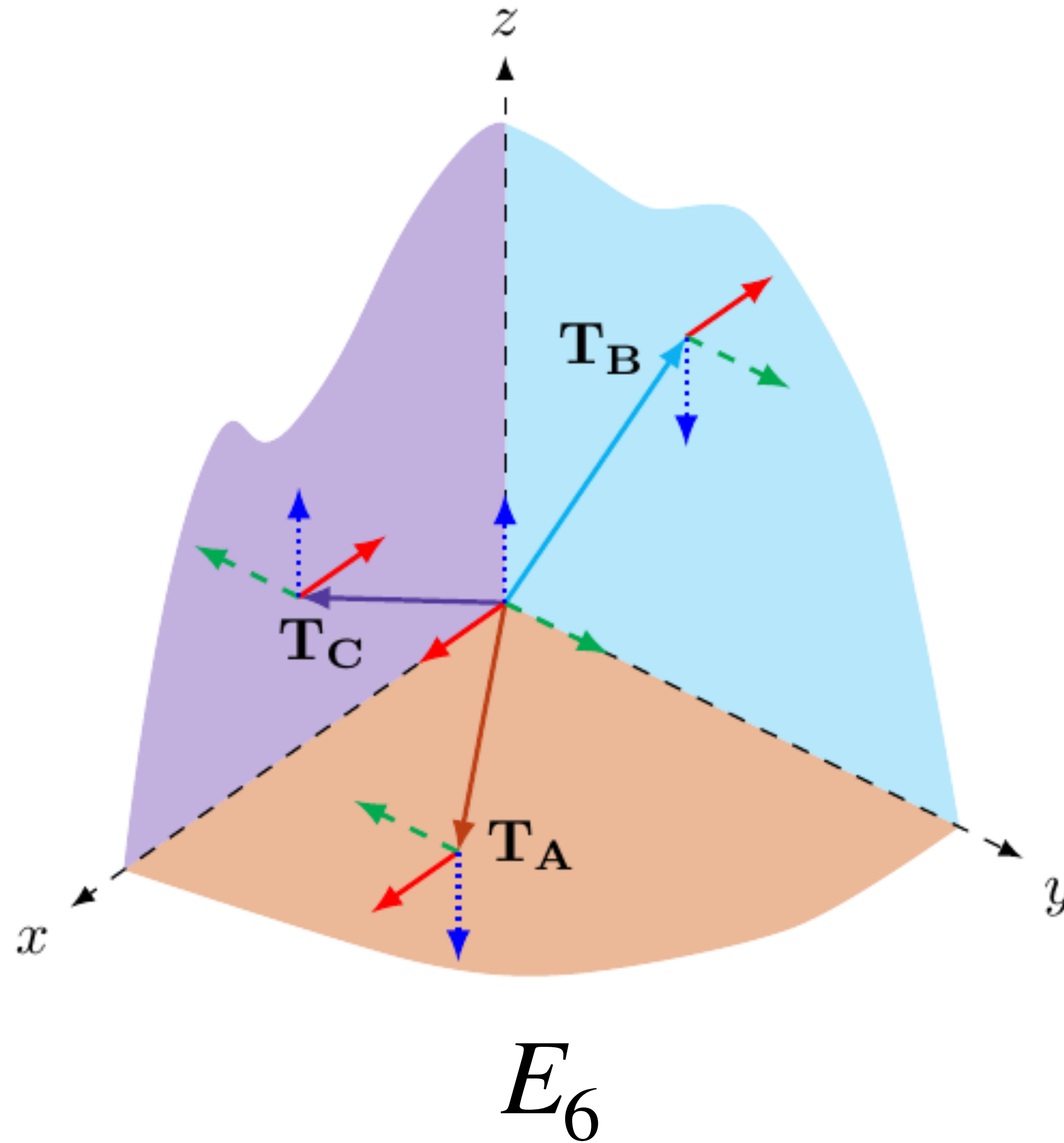


E_{16i}



E_{17}

Hantzsche-Wendt topology



Classification of topologies

Classification of topologies



ORIENTABLE

Classification of topologies



ORIENTABLE



FINITE

Classification of topologies



ORIENTABLE



FINITE



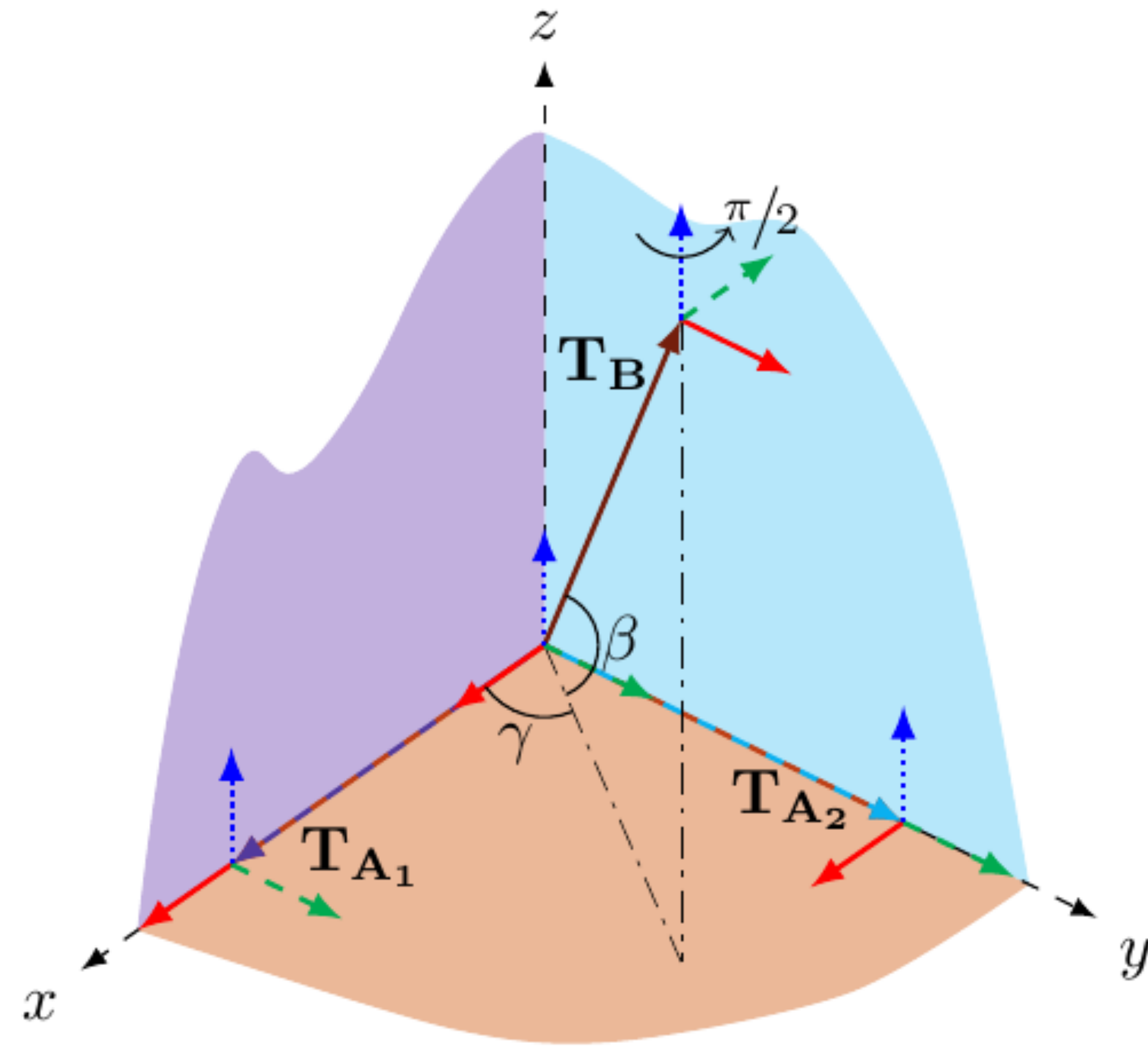
HOMOGENEOUS





200,000 units are ready, with a million more well on the way

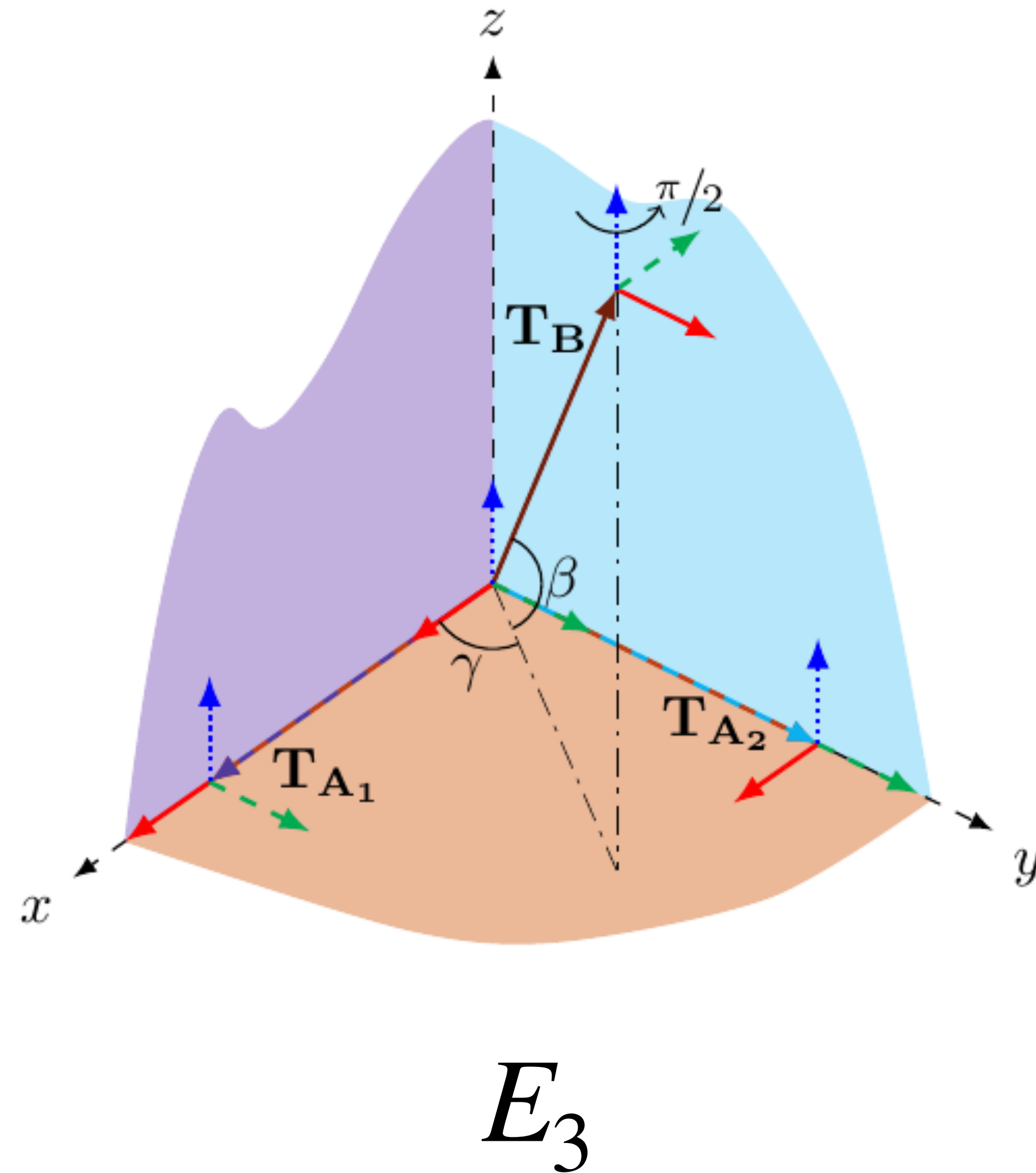
Clone search



E_3

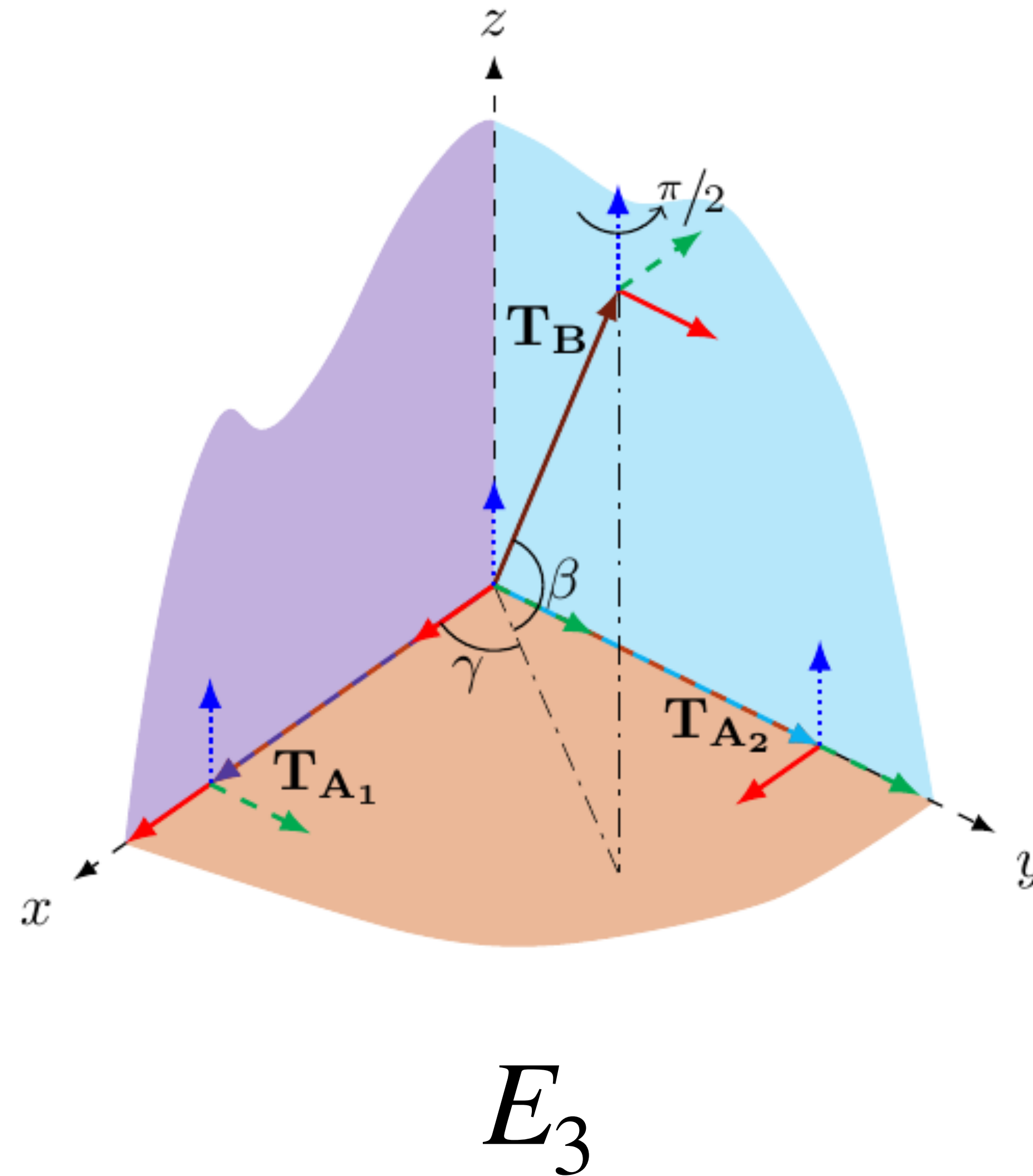
Clone search

Step 1:
Non-trivial
generators



Clone search

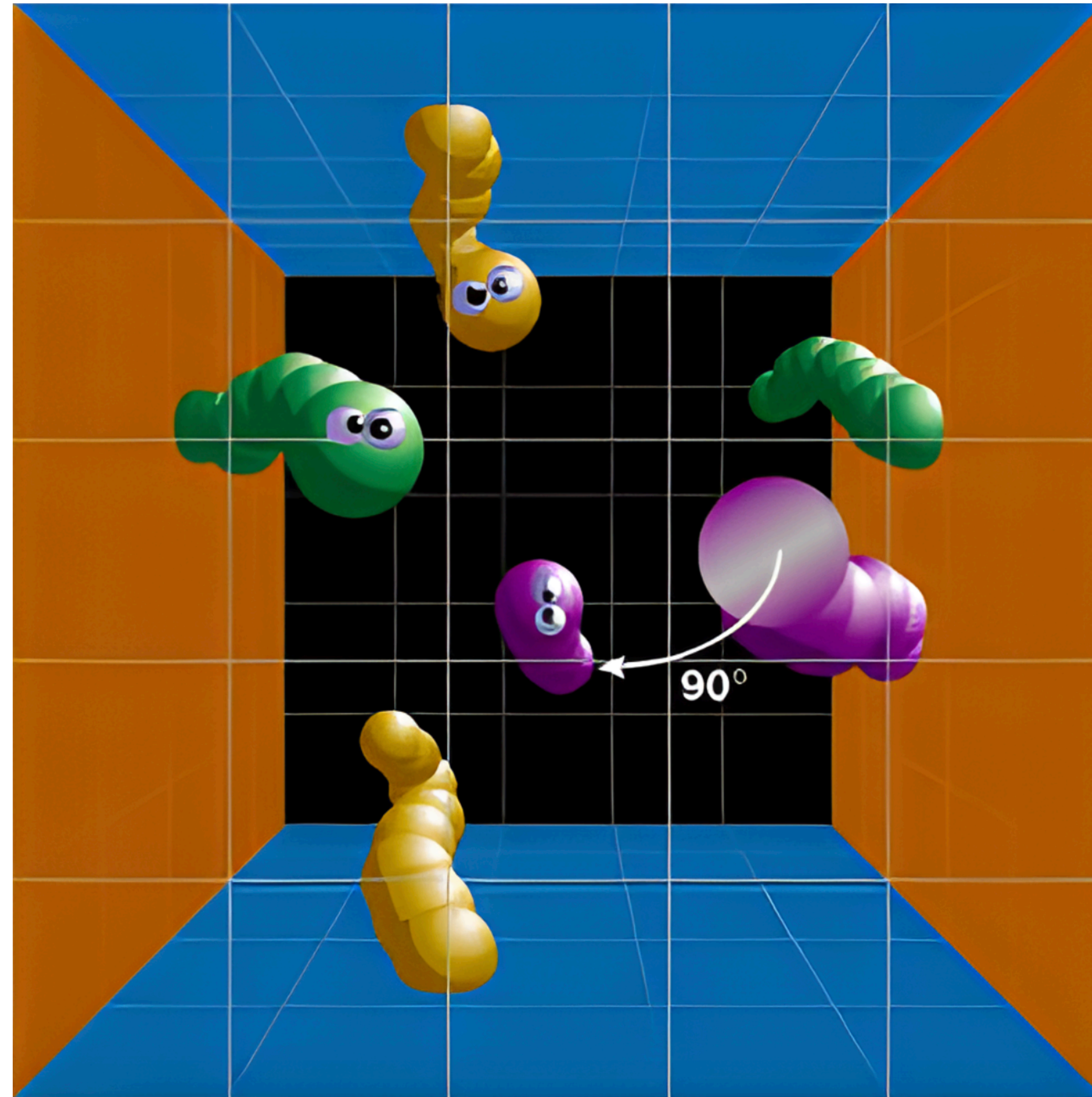
Step 1: Non-trivial generators



Step 2: Pure translations

Clone search

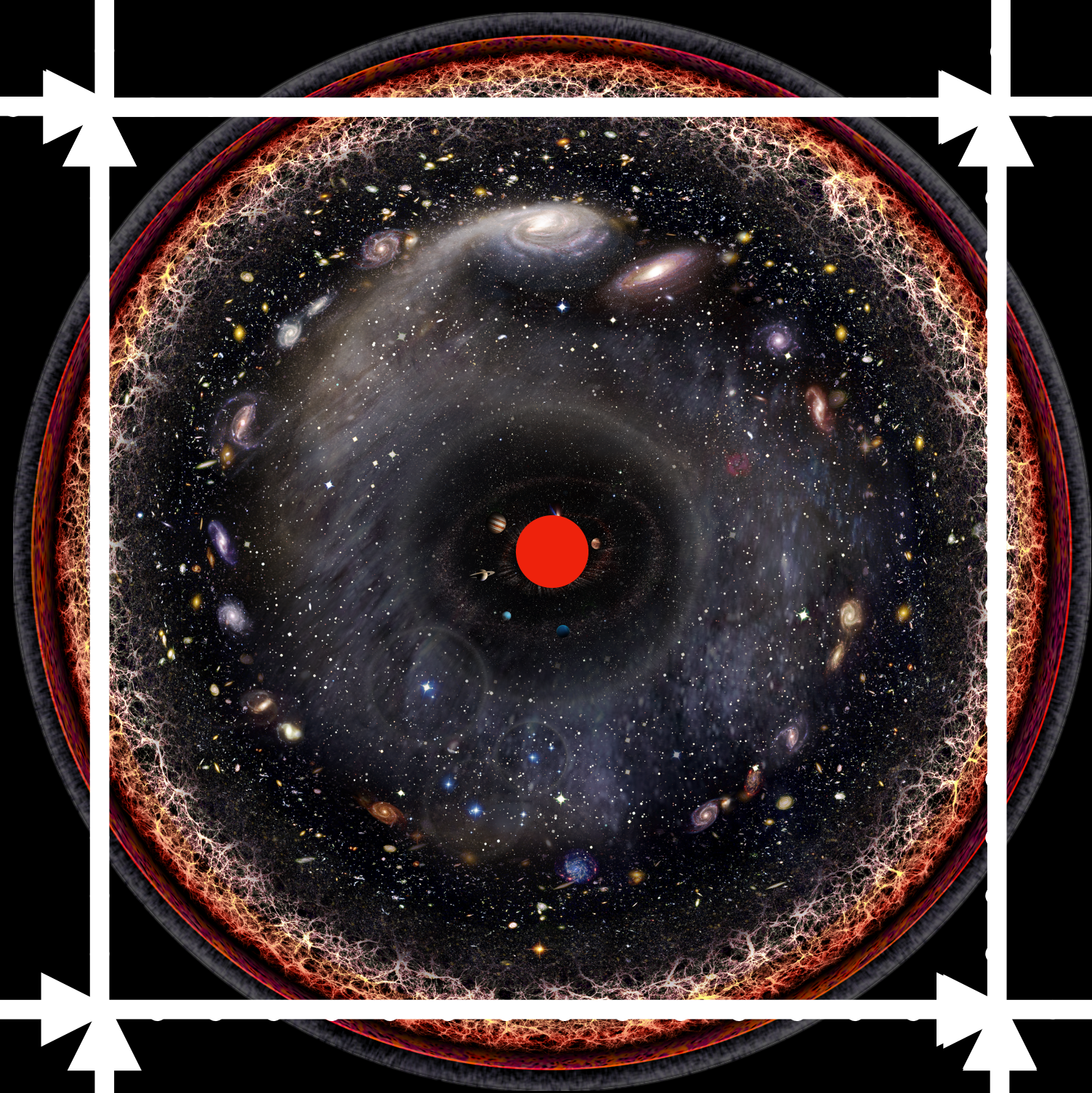
Step 1:
Non-trivial
generators

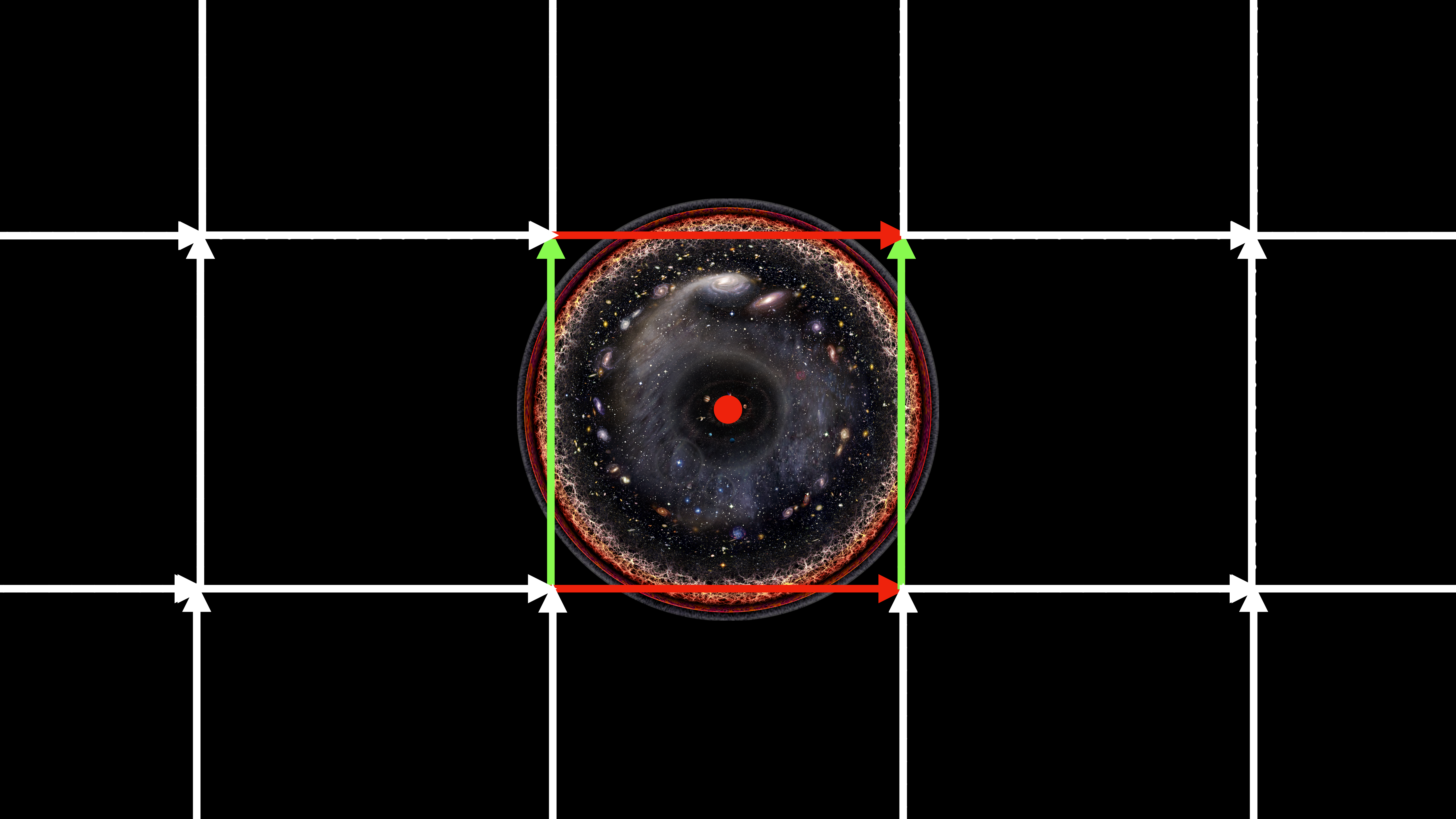


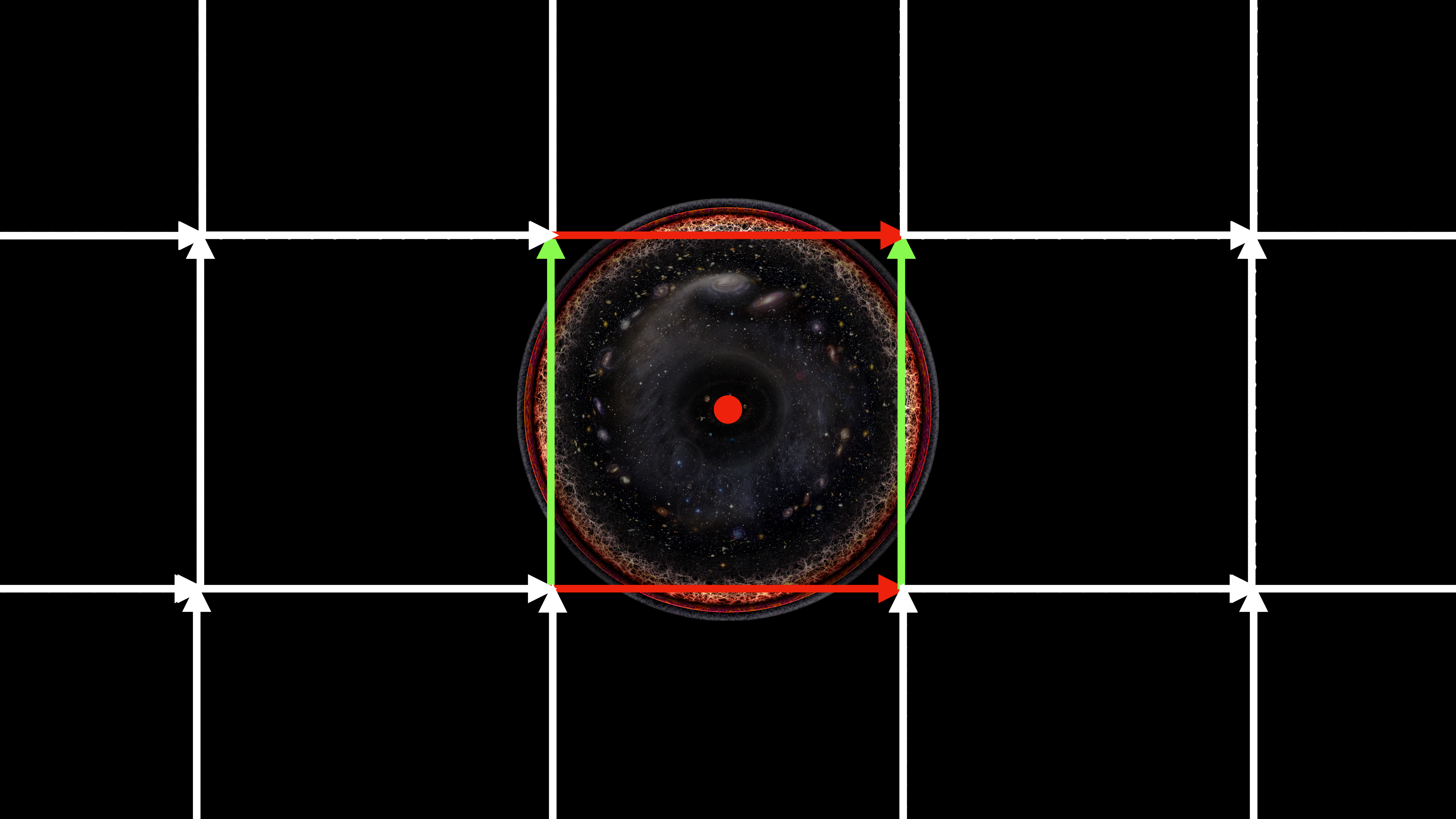
Step 2:
Pure
translations

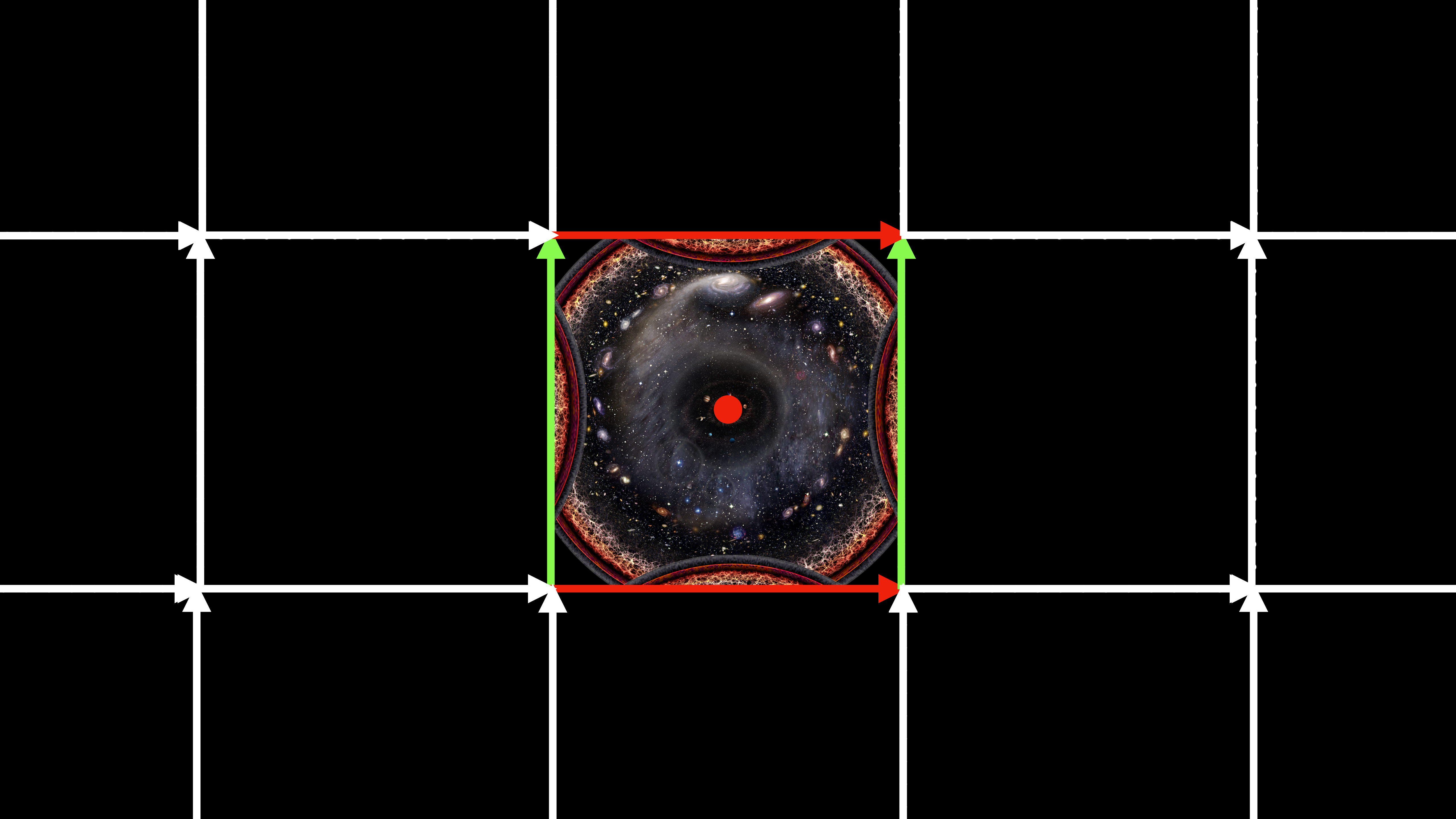
E_3

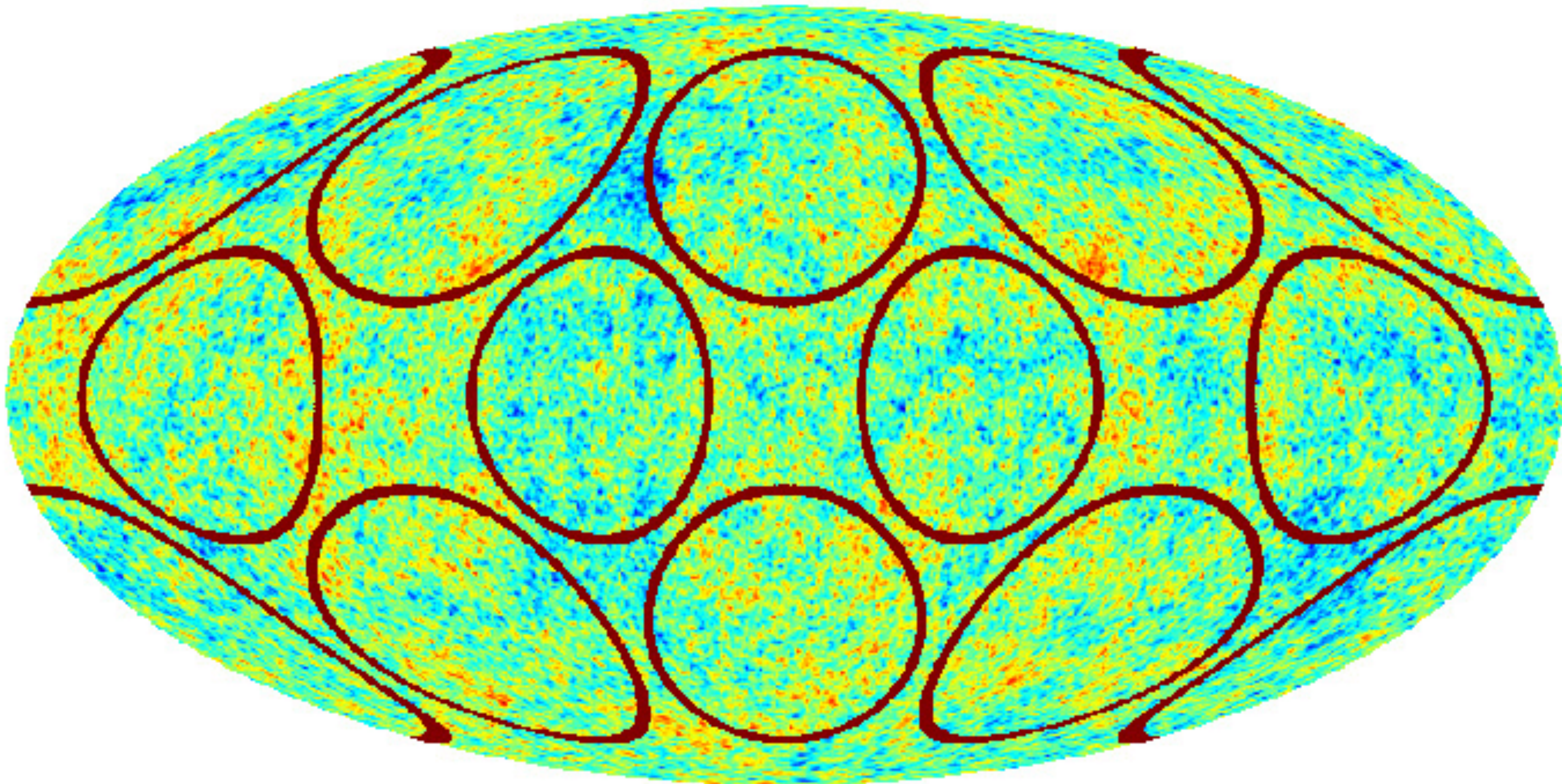










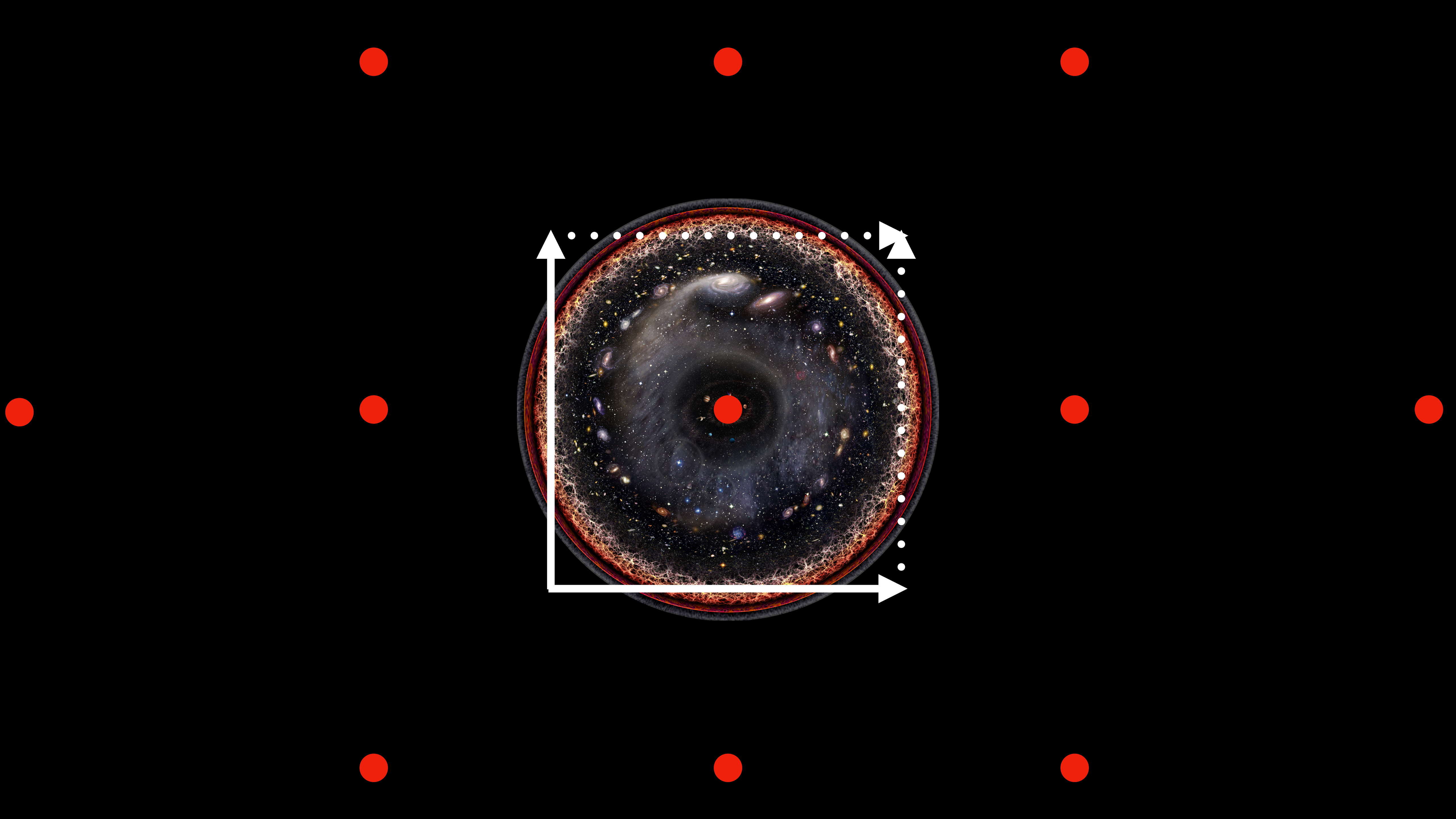


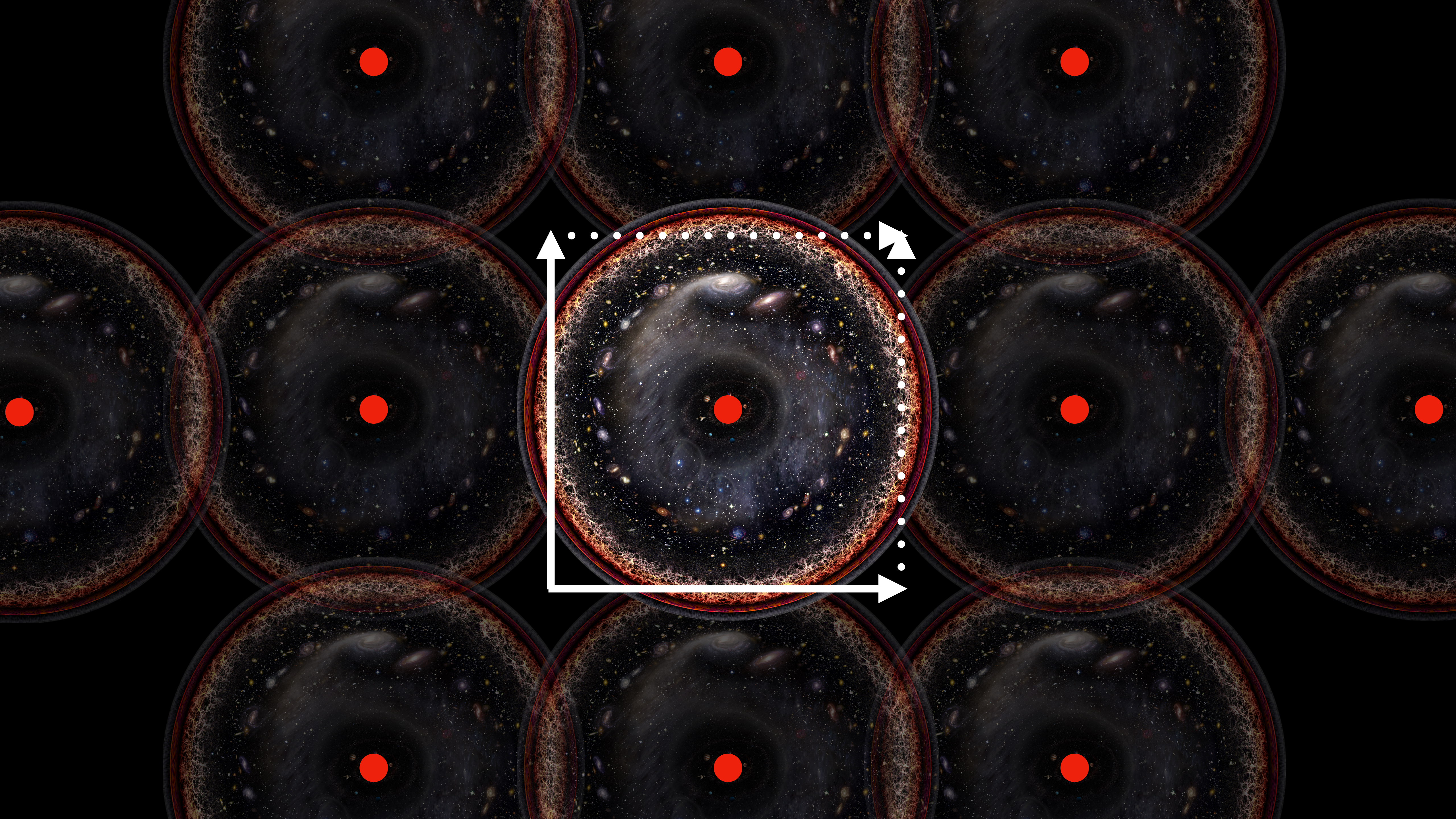
arXiv:1303.5086

arXiv:1502.01593

arXiv:1206.2939

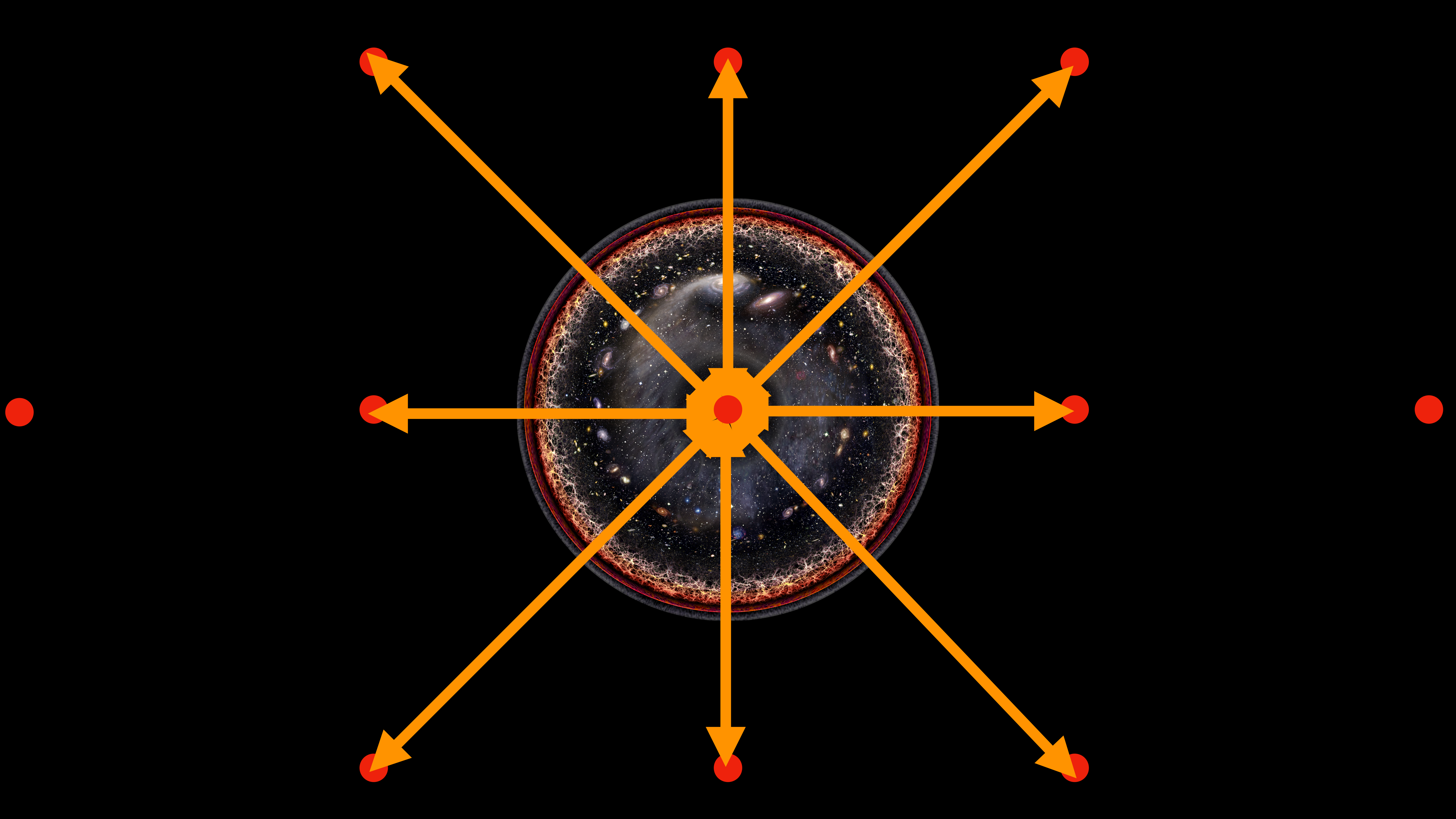


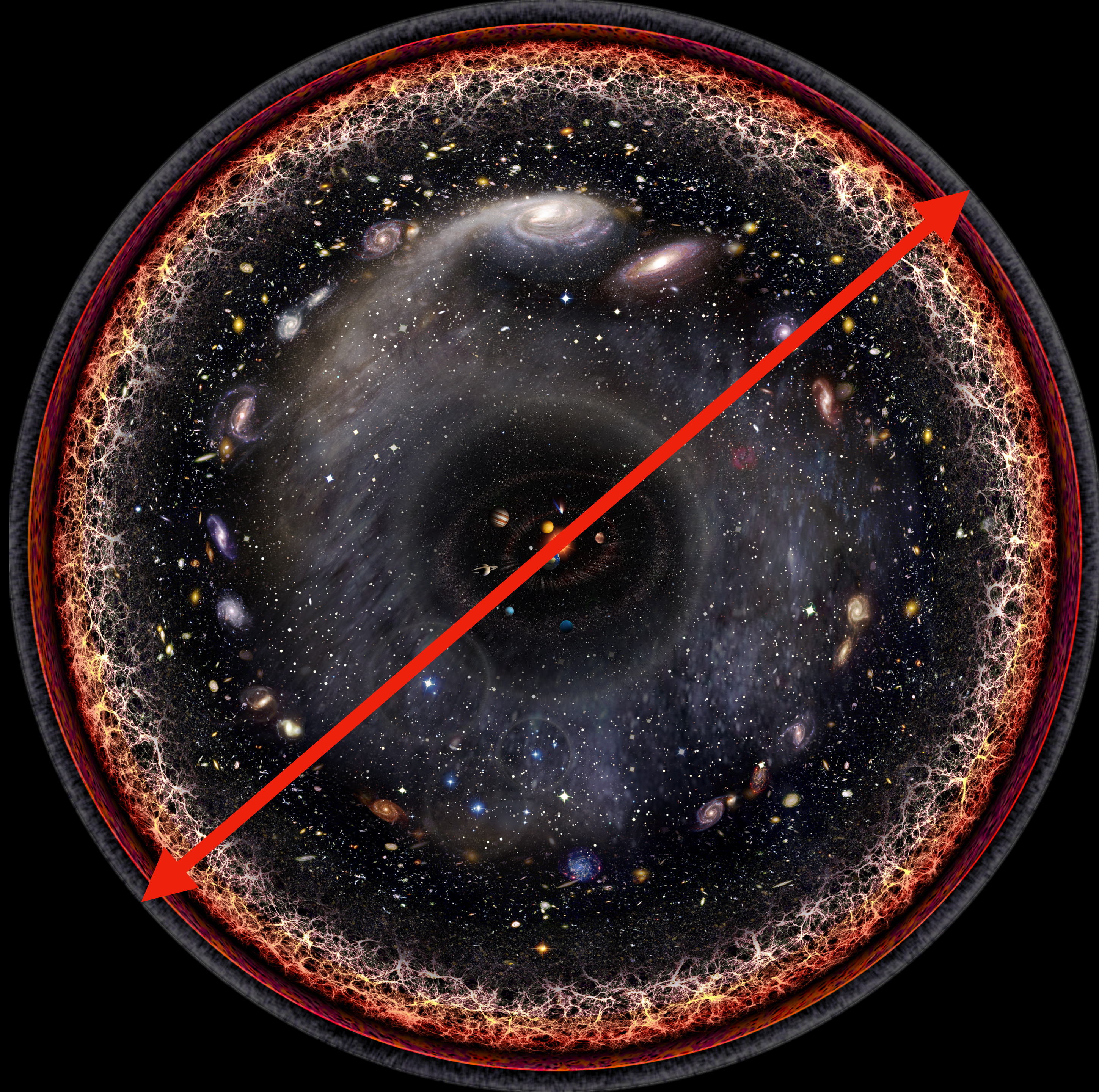


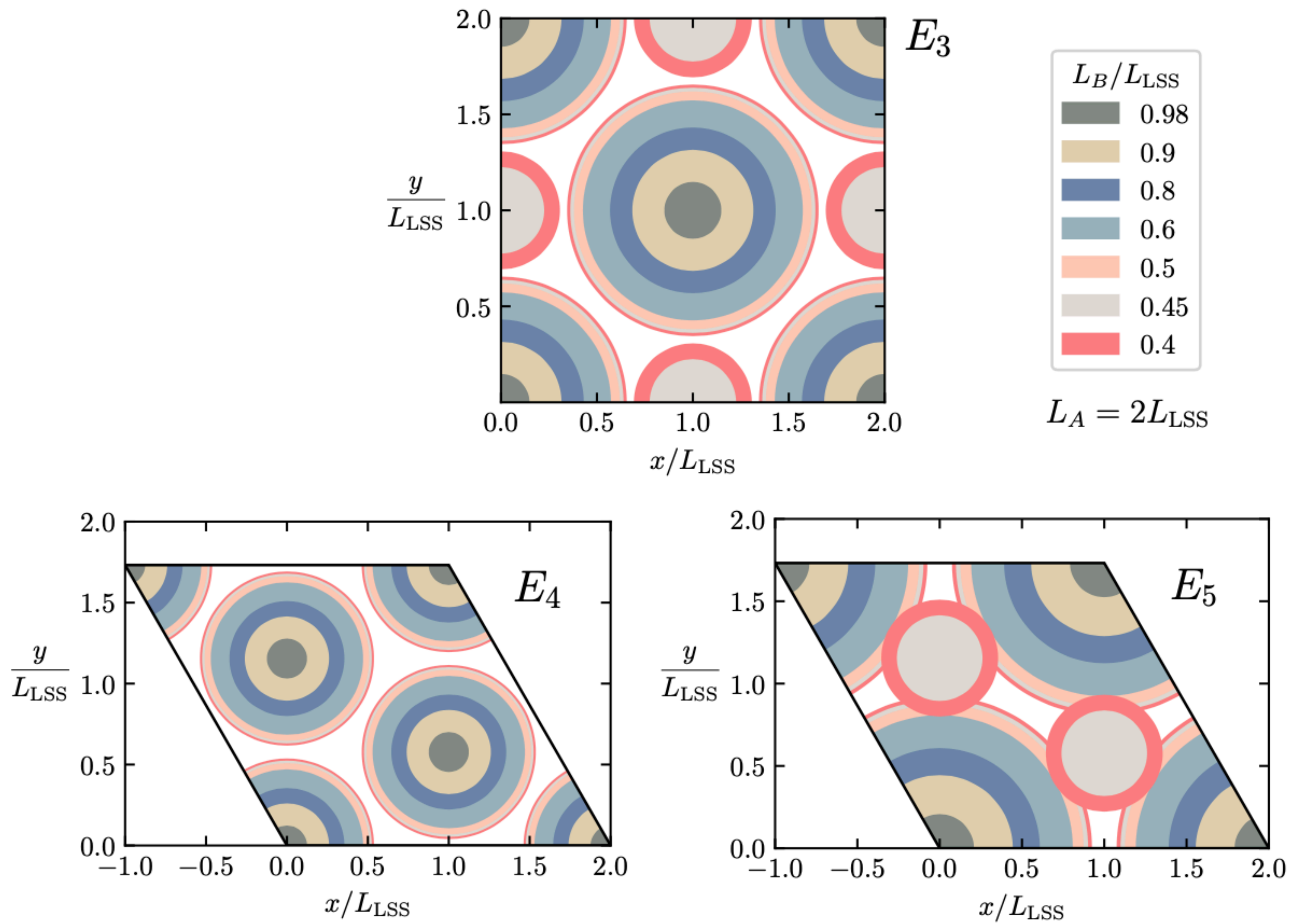


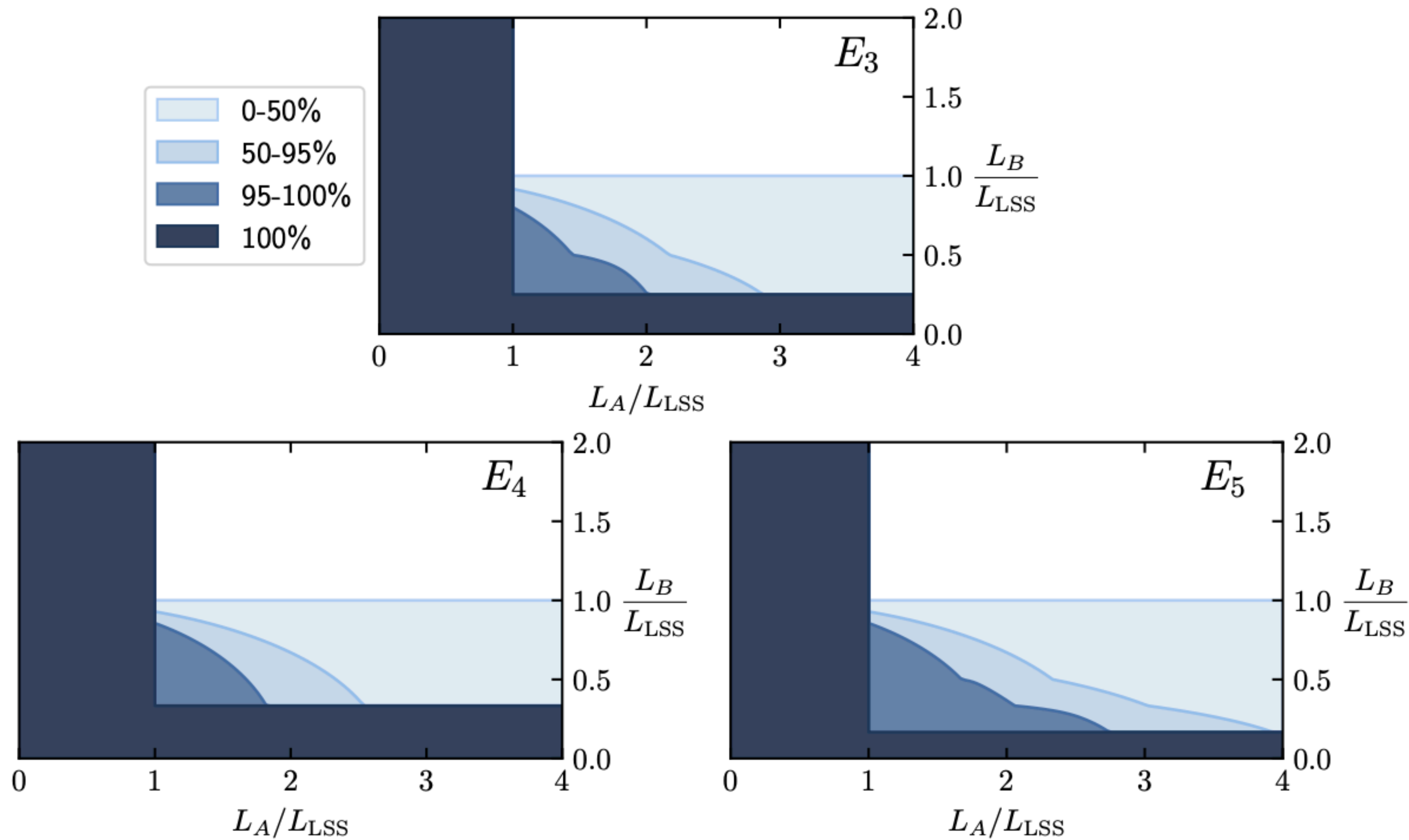


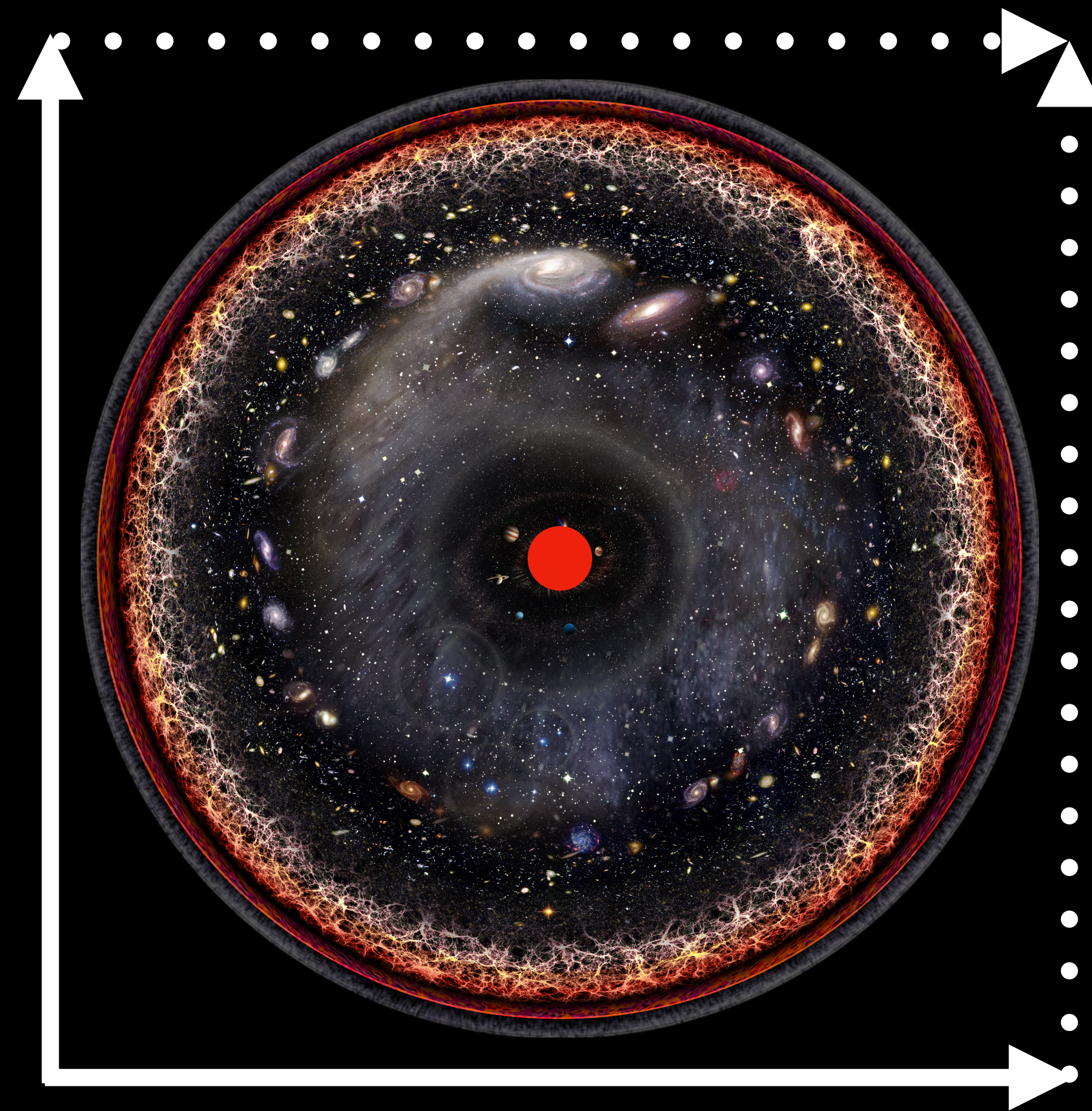


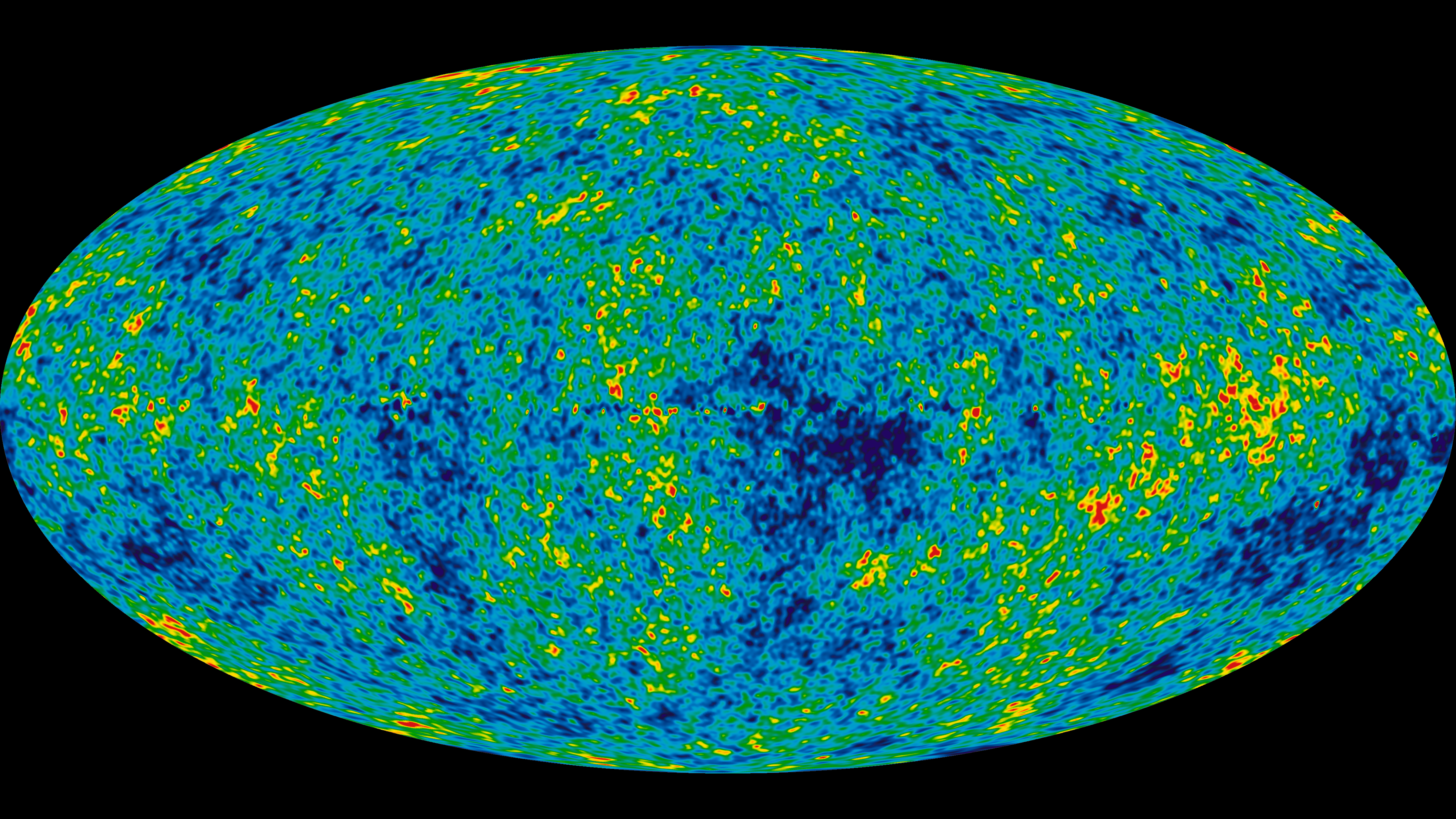


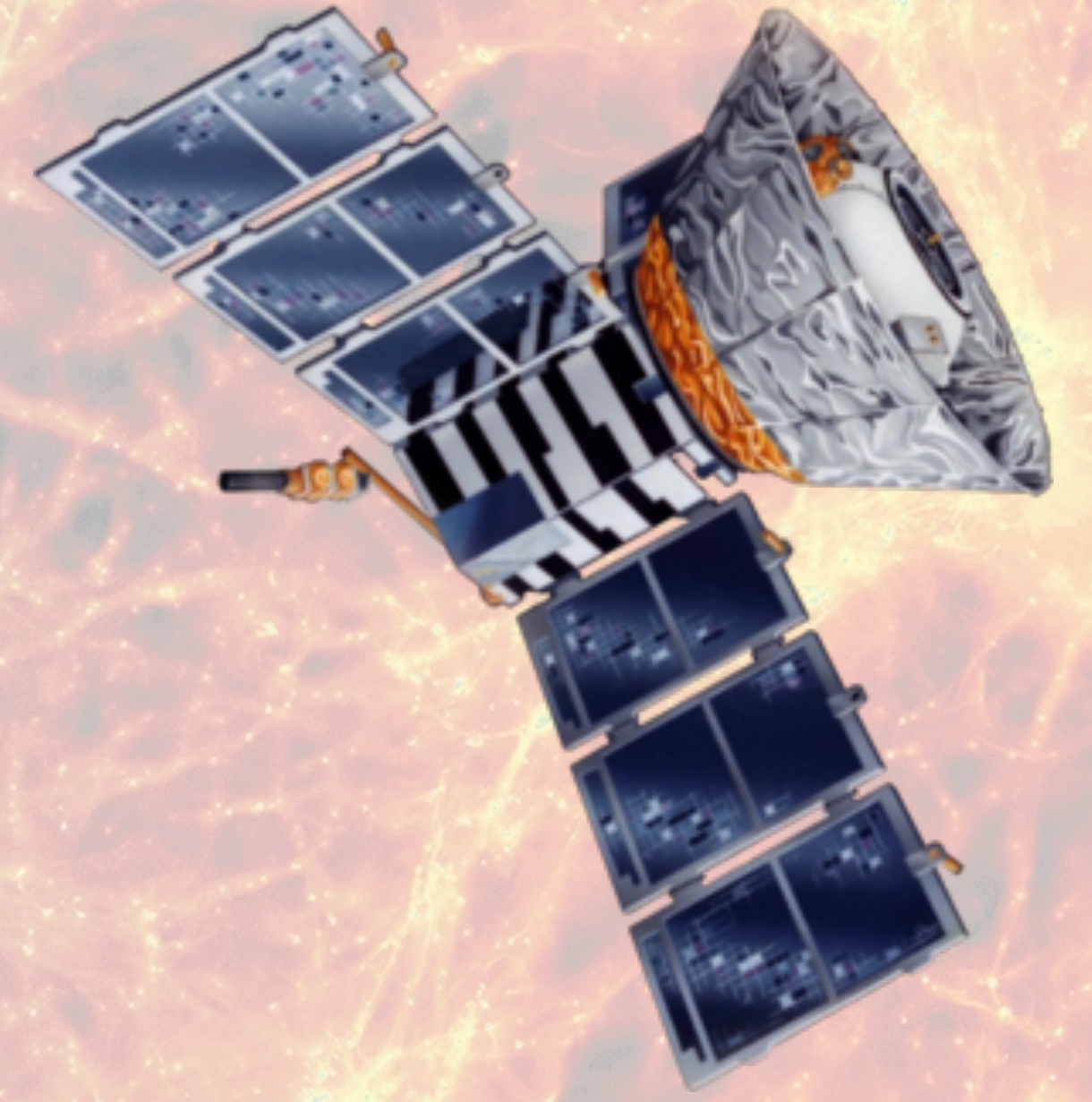
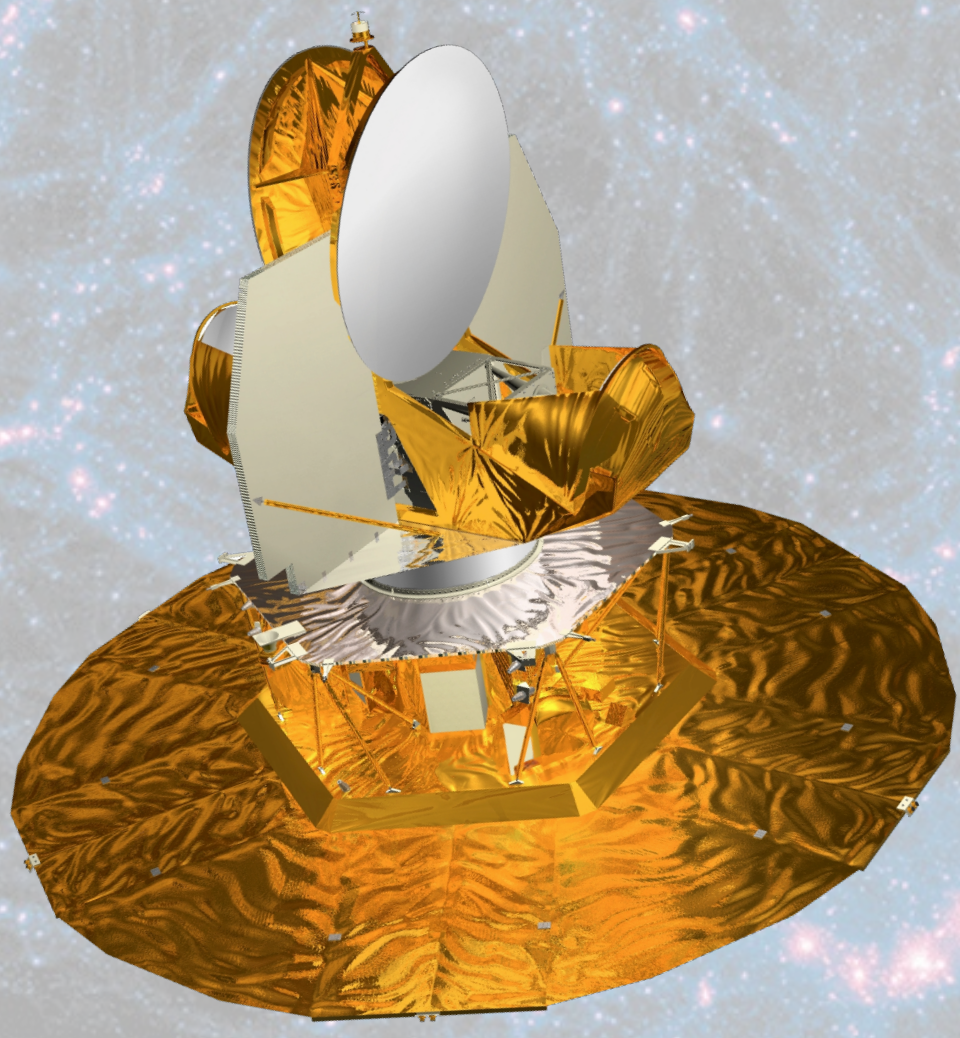




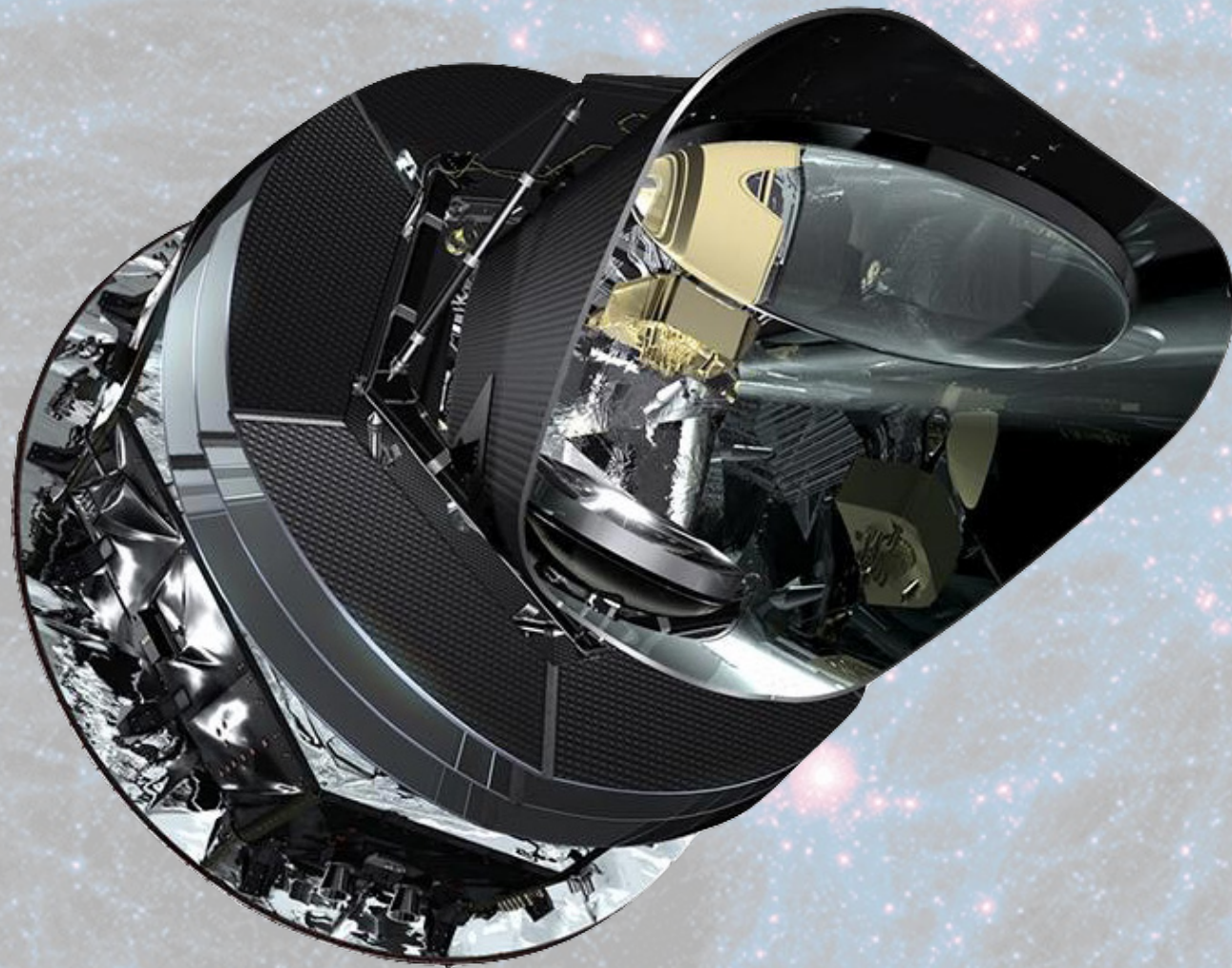


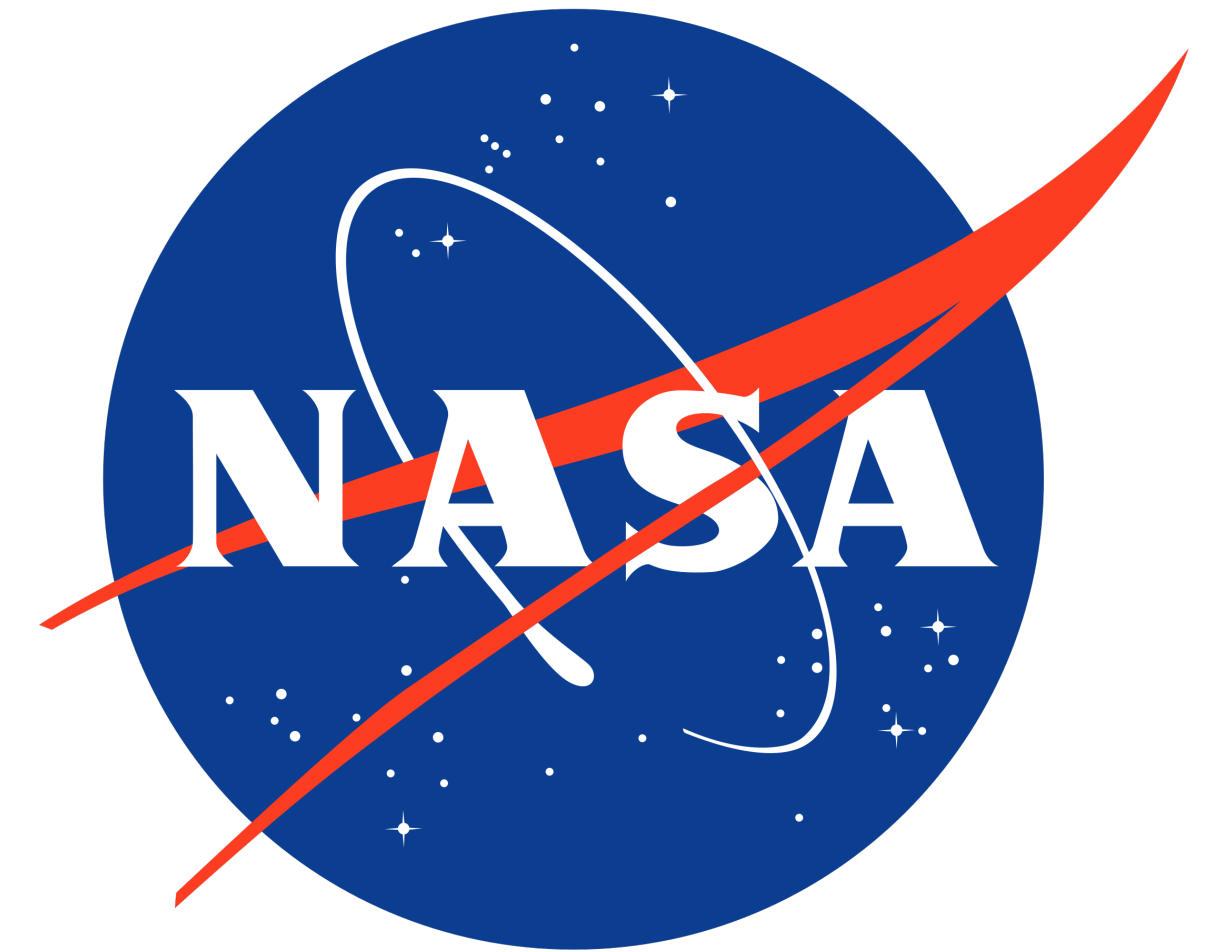






Summary





Questions?



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