

Okay, let's break down this fascinating simulation scenario. It involves complex packing dynamics under idealized frictionless conditions.

Understanding the Setup:

Environment: A 100m x 100m x 100m cube, frictionless walls, filled with frictionless water.

Objects: 1,000,000 dodecahedrons, ~0.99m diameter, density matching water (neutrally buoyant), frictionless surfaces.

Initial State: Arranged in a 100x100x100 simple cubic lattice. The ~0.99m diameter means there's initially a small gap (~1cm) between the bounding boxes of adjacent dodecahedrons.

Initial Motion: Rotating. Neighbors in the same XY plane rotate oppositely. Neighbors along the Z-axis (poles) rotate in the same direction. This creates columns (along Z) where all dodecahedrons rotate the same way, and adjacent columns rotate oppositely.

Visuals: Rotating = transparent; Stopped = black.

Process: One new dodecahedron added per second until full.

Key Question: How does the jamming (stopping of rotation) process occur? Specifically about the first cluster and subsequent growth.

Analysis:

Frictionless Nature: This is critical. In a truly frictionless system, rotation only stops due to physical impossibility – i.e., geometric jamming. Collisions are perfectly elastic, conserving energy and momentum (potentially transferring rotational to linear or changing axes, but not inherently stopping rotation unless jamming occurs). The water's frictionlessness means no viscous damping.

Initial Packing: A simple cubic lattice is not the densest packing for spheres or dodecahedrons. There's void space. The 0.99m diameter in a 1m grid cell leaves gaps.

Rotation: Rotating dodecahedrons sweep out a volume larger than their static volume. The alternating rotation in the XY plane creates shear zones between columns, but without friction, this doesn't directly cause slowing.

Adding Dodecahedrons: This increases the overall number density. The new dodecahedrons must find space, likely migrating towards the existing voids. This process increases local pressure and forces interactions between the existing rotating dodecahedrons.

Jamming Mechanism: As density increases, the space available for rotation diminishes.

Eventually, a dodecahedron will be contacted by its neighbors in such a way that its vertices cannot move past theirs. It becomes geometrically constrained and stops rotating. Because it's frictionless, this requires simultaneous constraint from multiple neighbours.

Where Jamming Starts: In a perfectly symmetrical setup, jamming is most likely to initiate where the constraints are highest. This is typically furthest from any free surface or wall – i.e., near the geometric center of the pool. Dodecahedrons there are surrounded on all sides. As the added dodecahedrons fill voids and effectively increase pressure/packing density, the central region feels this confinement most acutely.

Answering Question 1:

Is the first structure of blocked dodecahedrons formed by 7 dodecahedrons in the central plane?

The Number 7: A dodecahedron in the simple cubic lattice has 6 immediate neighbours (up,

down, left, right, front, back). For the central dodecahedron (let's call it D0) to become completely jammed, it likely needs to be constrained by several, if not all, of these 6 neighbours (N1-N6). If D0 stops, and this immediately causes N1-N6 to also stop (because their rotation is now blocked by the static D0 and potentially each other), then you have a stable, non-rotating cluster of 7 dodecahedrons (D0 + N1 + N2 + N3 + N4 + N5 + N6). This 7-unit cluster (a central body and its first coordination shell in the cubic lattice) is the smallest fully surrounded unit, making it a plausible candidate for the first stable jammed structure.

"In the Central Plane": This phrasing is slightly ambiguous. It likely means located near the geometric center of the pool. A single geometric plane (e.g., $z=0$) in the cubic lattice would only contain D0 and 4 neighbours ($\pm x, \pm y$ directions). The 7-unit structure is inherently 3D. So, it's plausible the first jamming event involves these 7 dodecahedrons located around the pool's center point.

Conclusion (Q1): Yes, it is plausible and geometrically logical that the first stable structure of non-rotating dodecahedrons consists of a central one and its 6 immediate lattice neighbours (total 7), located near the geometric centre of the pool due to maximum initial constraint.

Answering Question 2:

Do the next structures form as assemblies of 7 stuck dodecahedrons in every successive plane?

Growth Pattern: Once the initial central cluster (C7) is jammed, it forms a static obstacle. The dodecahedrons immediately adjacent to this C7 cluster are now the most constrained. They interact with both rotating neighbours and the newly static faces of C7. It's highly likely they will be the next to jam. This suggests the jammed region will grow outwards from the initial nucleation site (C7).

"Assemblies of 7": It is unlikely that the growth proceeds by adding distinct, pre-formed "7-packs". Jamming is a local phenomenon. A dodecahedron stops when its local environment prevents rotation. The jammed region will likely expand dodecahedron by dodecahedron at its boundary, rather than in discrete 7-unit chunks.

"In Every Successive Plane": This implies a very ordered, layer-by-layer growth (e.g., filling the $z=0$ plane completely, then $z=1$ and $z=-1$, etc.). While the initial lattice provides structure, jamming propagation depends on complex local force chains and geometry. It's more likely the jammed region grows somewhat spherically or cubically outwards from the center, rather than strictly plane by plane. The boundary of the jammed region might be rough or irregular.

Conclusion (Q2): The jammed region will likely grow outwards from the initial central cluster. However, it's unlikely to grow by adding discrete 7-dodecahedron assemblies or to proceed strictly plane by successive plane. Growth is expected to be more continuous, expanding the boundary of the jammed region dodecahedron by dodecahedron, likely in a roughly 3D (spherical/cubical) manner.

Summary:

Q1: The hypothesis of the first jammed structure being a 7-dodecahedron unit (central + 6 neighbours) near the pool's center is plausible due to maximum constraints in the center.

Q2: The jammed region will likely grow outwards from this center, but probably not by adding discrete 7-unit blocks or strictly layer by layer in planes. A more continuous, roughly 3D

expansion of the non-rotating core is expected.

This simulation describes a complex granular physics problem (jamming transition) in an idealized setting. The frictionless condition makes geometry the sole factor in stopping rotation.