Gravitational fields of tesseroids with variable density

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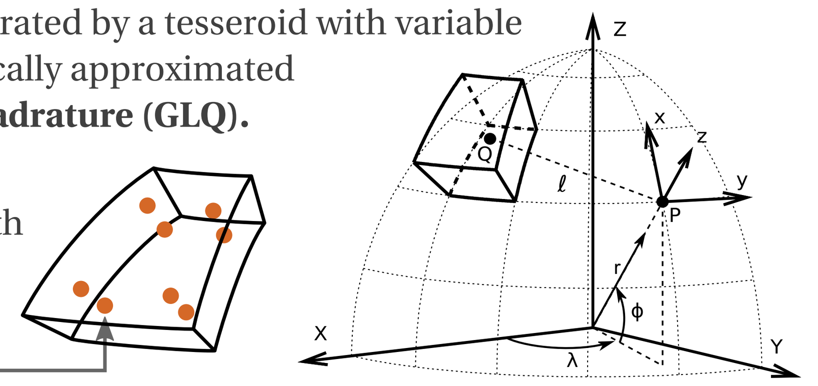
Introduction

When computing gravitational fileds on regional or global scales it's necessary to take into account the curvature of the Earth. One way to do this is using spherical prisms, also known as **tesseroids**. Most methodologies consider only Tesseroids with homogeneous, linear or polynomial densities in depth. We present a new methodology to compute the **gravitational fields** generated by **tesseroids** with any **continuous density** variation through a **Gauss-Legendre Quadrature** and **two discretization algorithms**.

Gauss-Legendre Quadrature

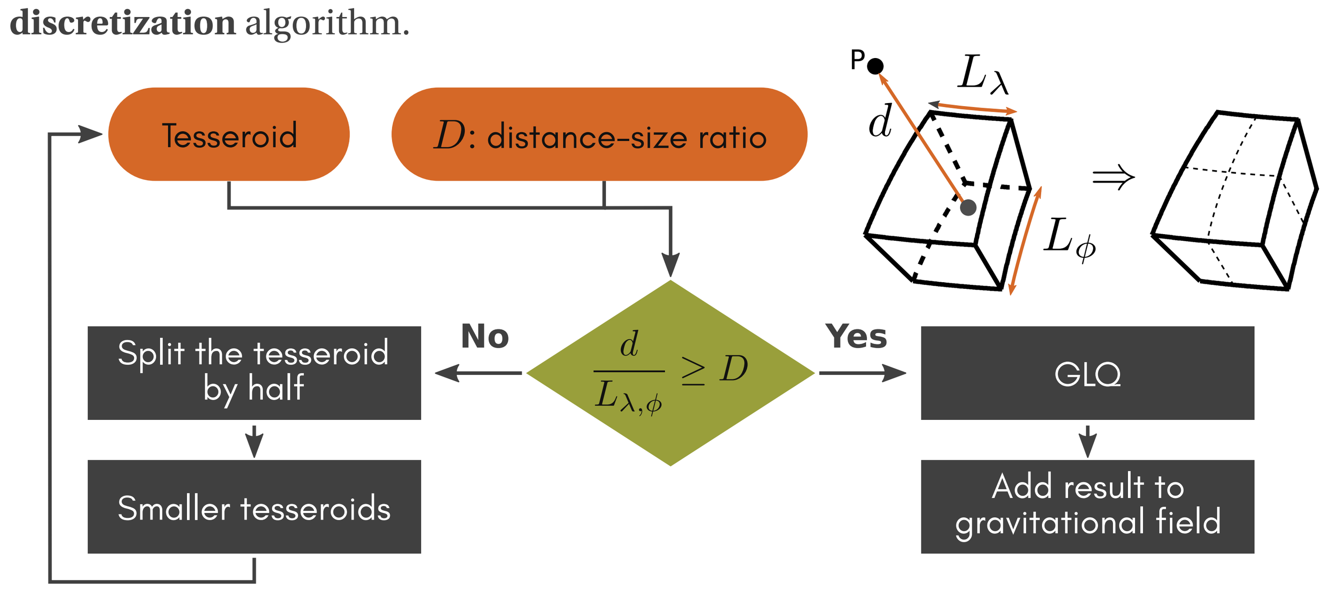
The gravitational potential generated by a tesseroid with variable density in depth can be numerically approximated throught a **Gauss-Legendre Quadrature (GLQ).**

The **GLQ is equivalent** to approximating the **tesseroid** with **point masses** located on the **nodes** of the Quadrature.



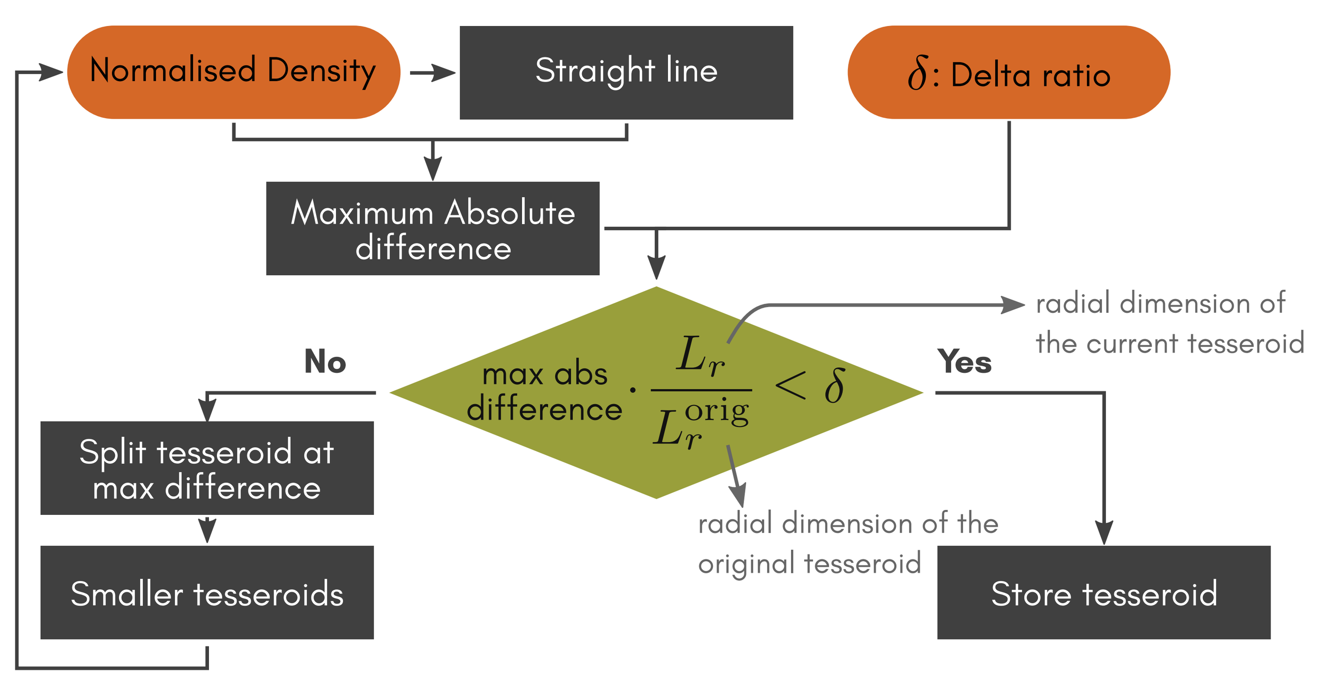
2D Adaptive Discretization

The **approximation** becomes **less accurate** when the **computation point** gets **closer** to the **tesseroid**. To reduce this error we use a **two dimensional adaptive discretization** algorithm.

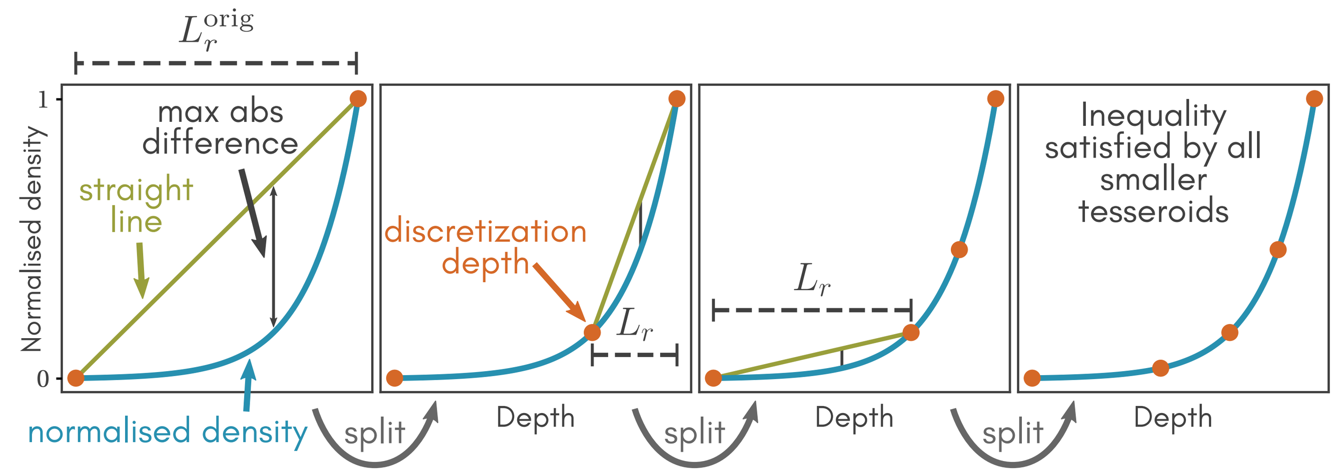


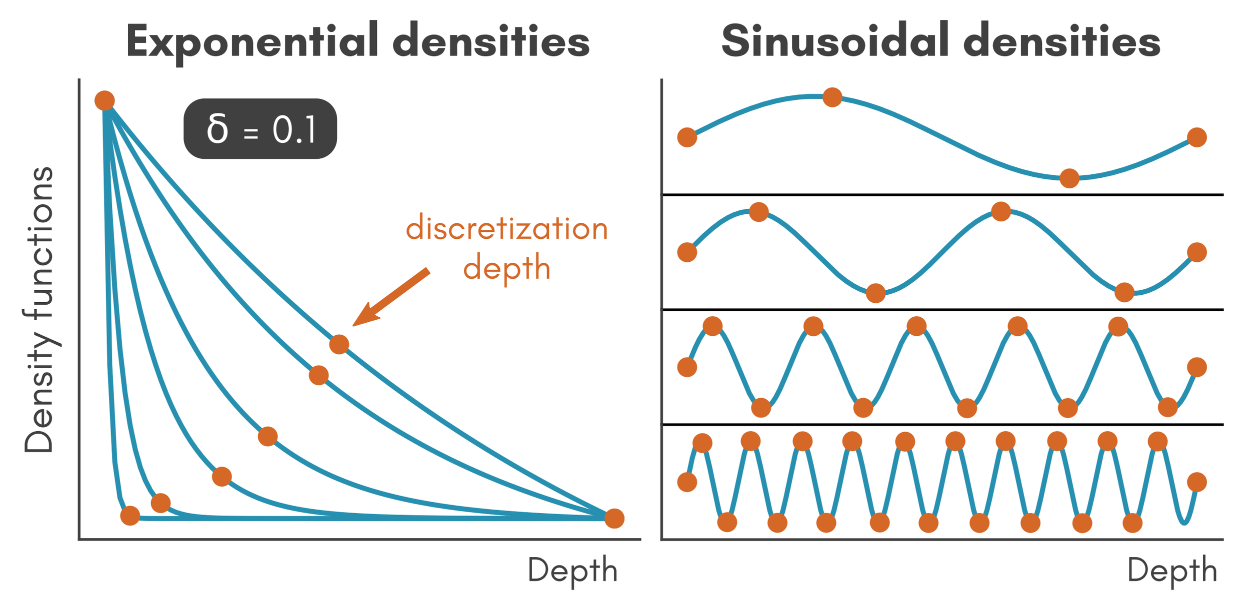
Density-based Discretization

We have developed a complementary discretization algorithm that reduces the errors due to the variations of the density function. In short, it **divides the tesseroid** along the **radial dimension** at the depths at which the ***maximum density variation*** takes place.



Density-based discretization examples

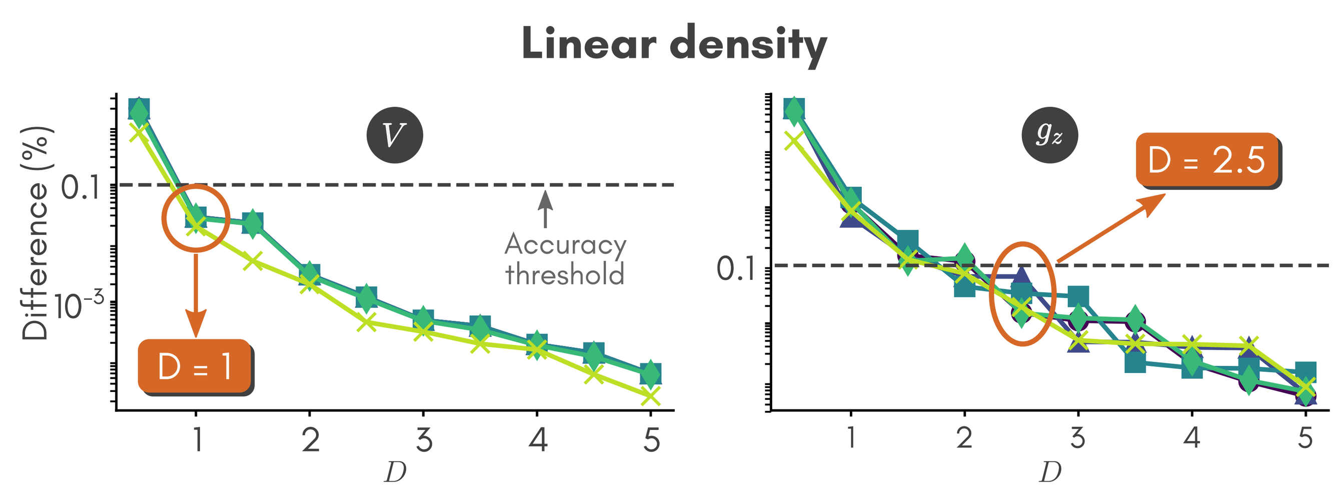


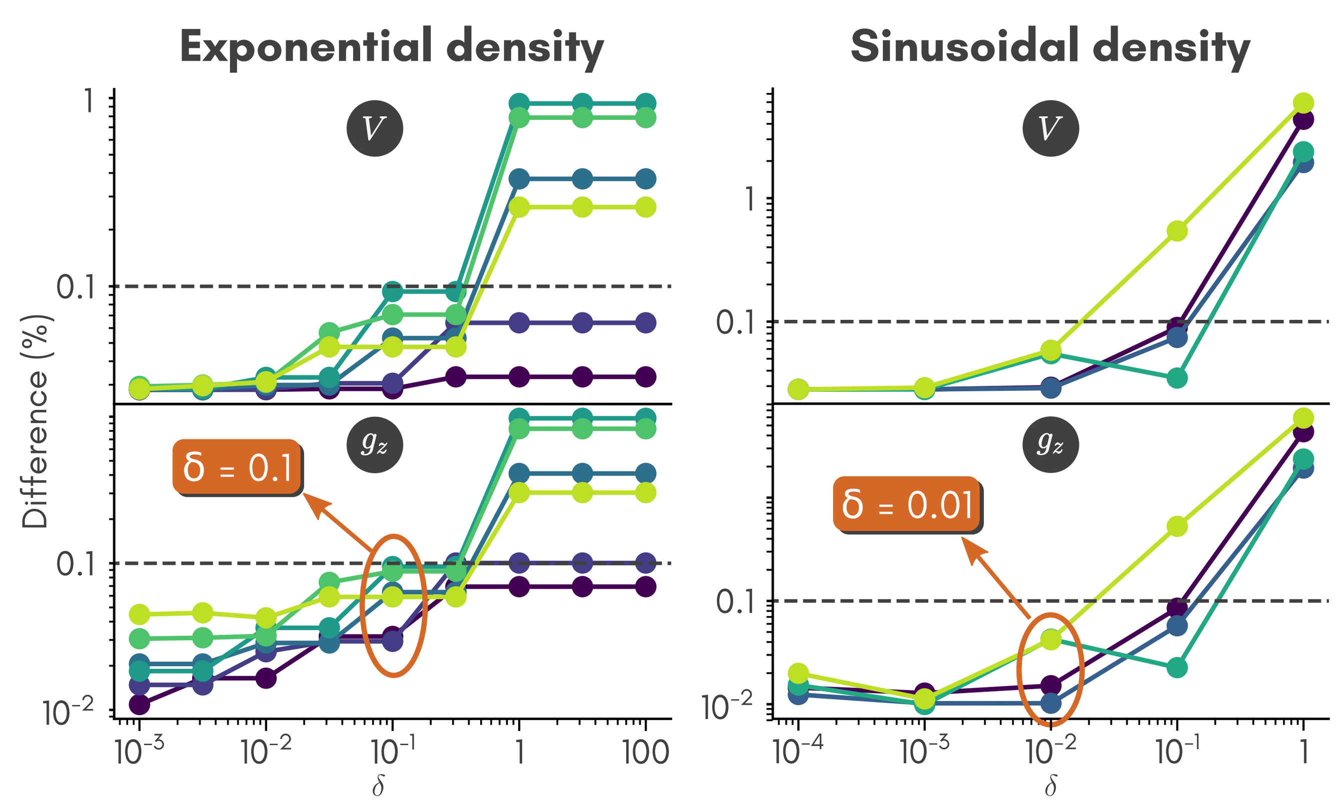


The **density-based discretization** adjust the **number of splits** depending on the **variability of the function.**

Determination of D and δ

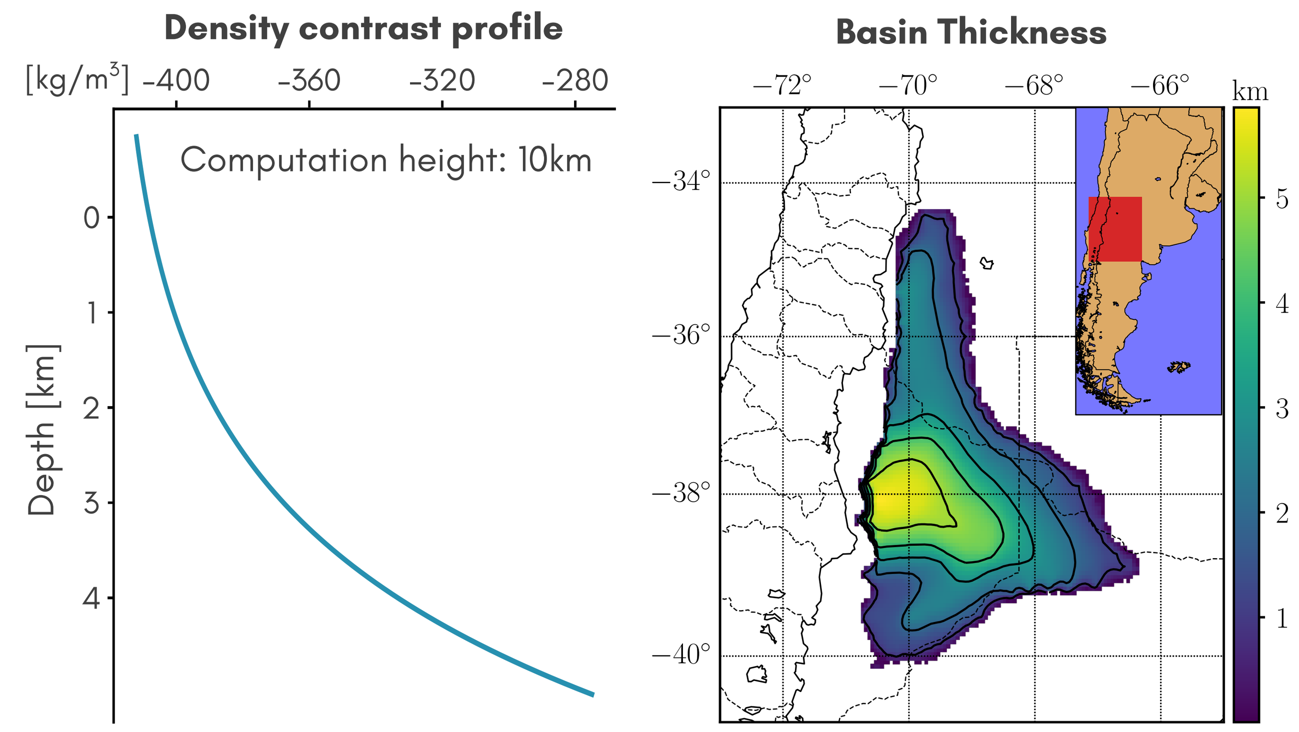
We want to find the optimal values of D and δ that guarantee accuracy while minimizing the computation time. In order to do that we **compared** the **numerical results** with the **analytical solutions** of a **spherical shell**.

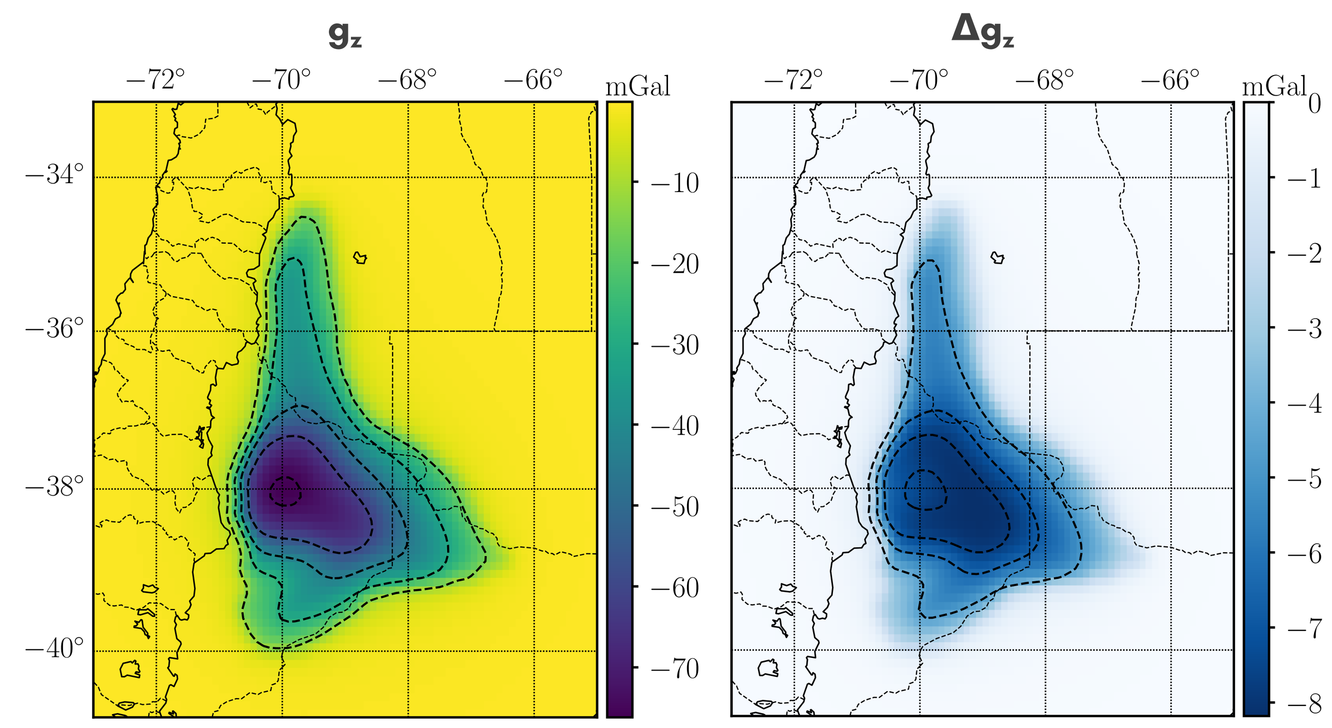




Forward Model: Neuquén Basin

We modelled the Neuquen basin using an exponential density profile in order to account for the compactation of the sediments.





Forward model with exp. density. Difference with constant density model.

Conclusions

- New **fully automated method** to compute **gravitational fields** of **continuous density tesseroids**.
- The **density-based discretization automatically** adjusts number of **radial splits**.
- **Linear density** tesseroids **don't need** density-based **discretizations**.
- To achieve a **0.1%** accuracy:
  - **D = 1** for potential,
  - **D = 2.5** for accelerations,
  - **δ = 0.1** sufficient for most geophysical applications.
- Gravitational fields of **sedimentary basins** show meaningful differences if the **density variation** is **taken into account**.

References

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Download the source code
github.com/pinga-lab/tesseroid-variable-density

Download the poster
github.com/santisoler/lapis2019

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