New force at large distances

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Institute for Theoretical Physics
Vienna University of Technology

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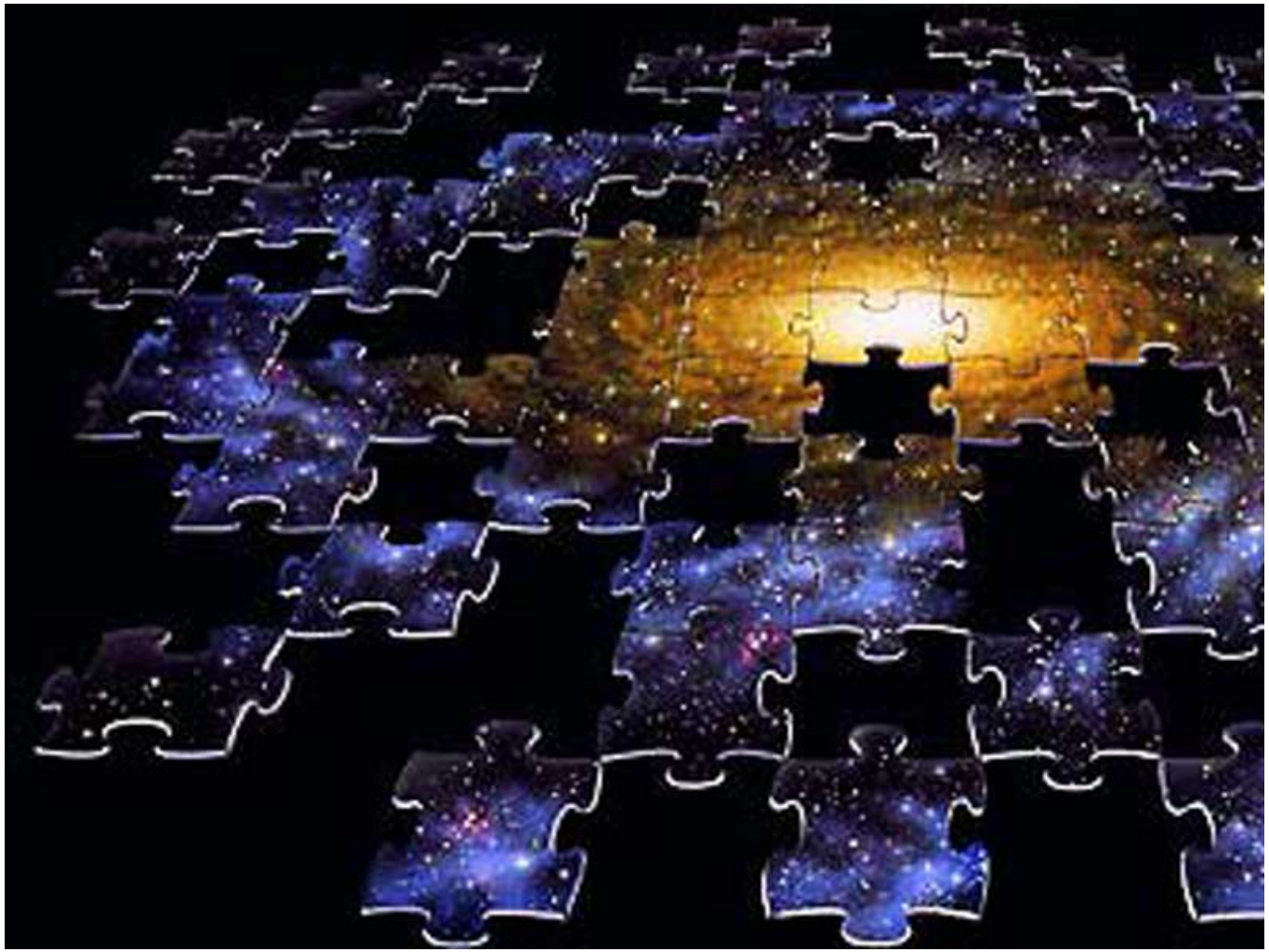
We live in the golden age of fundamental physics

Goal: want to understand how the Universe works

Some questions physics can address:

- What is the Universe made of? (picture by NASA)



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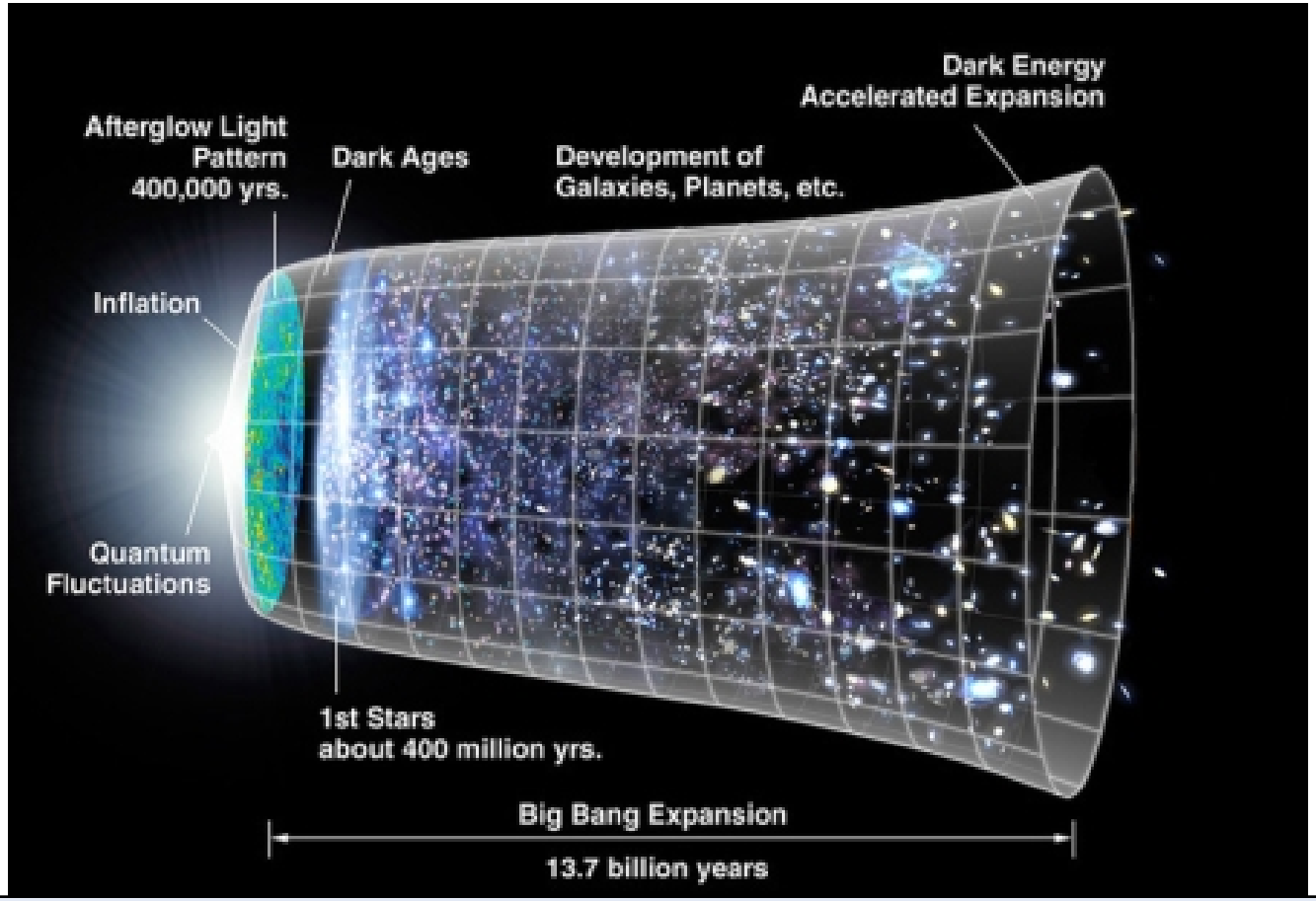

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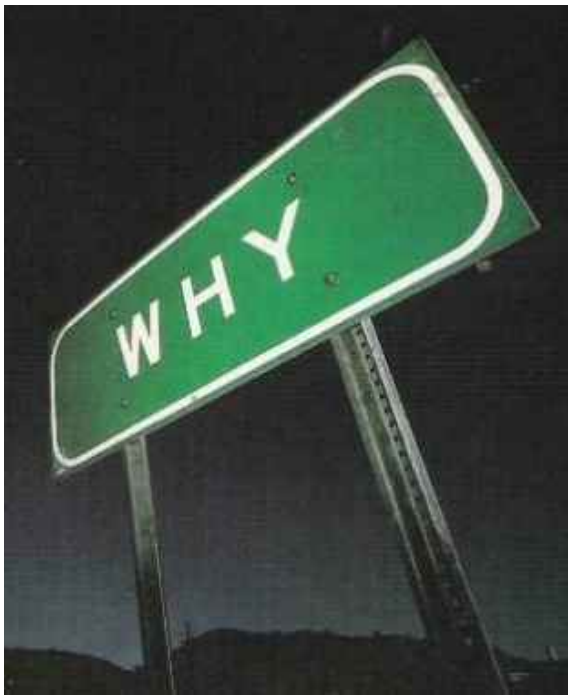

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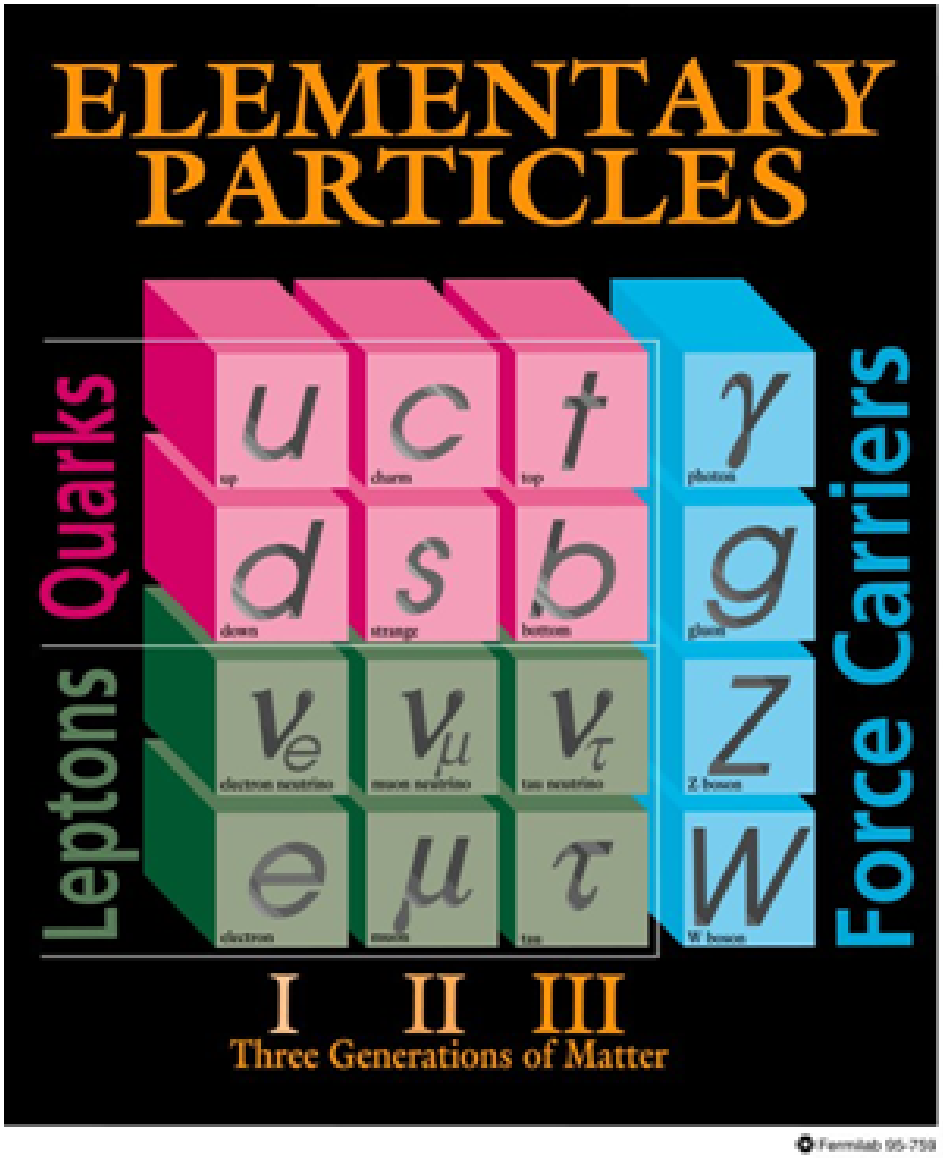

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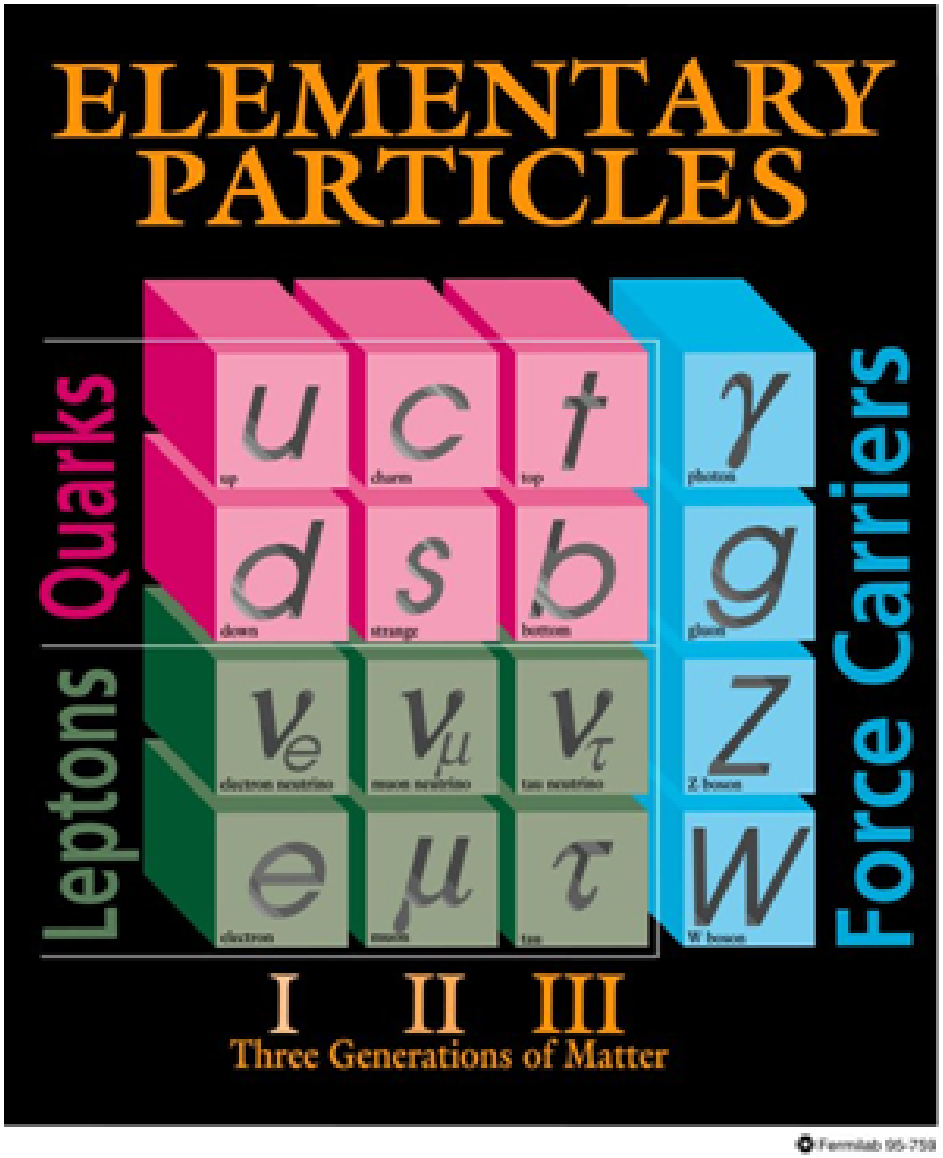

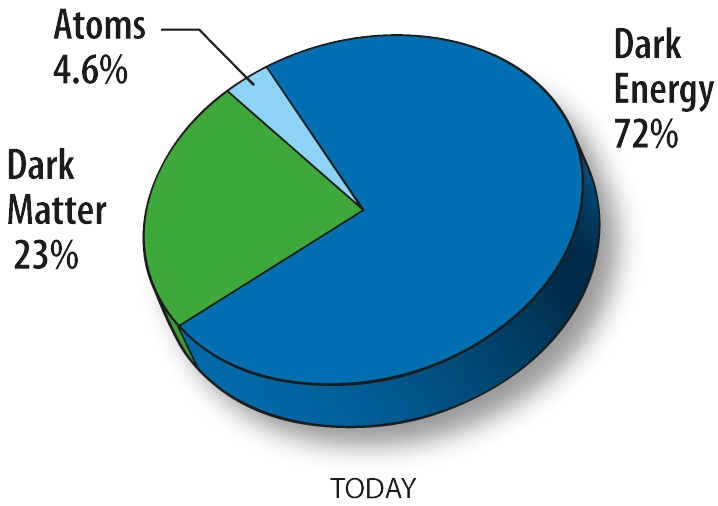

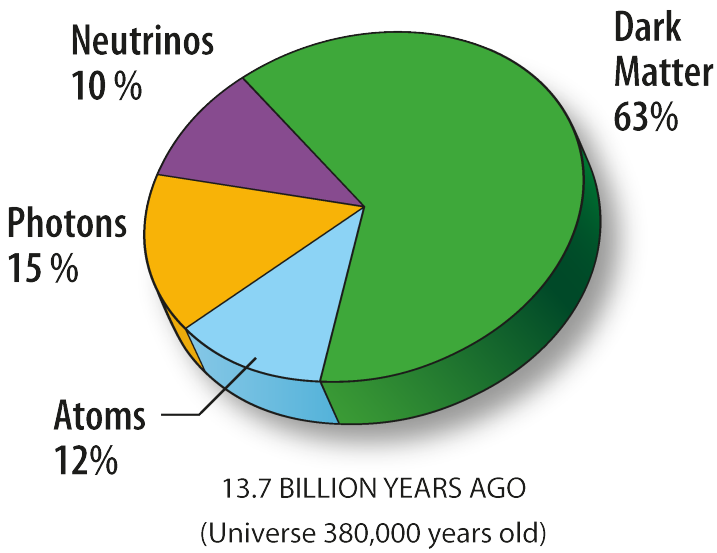

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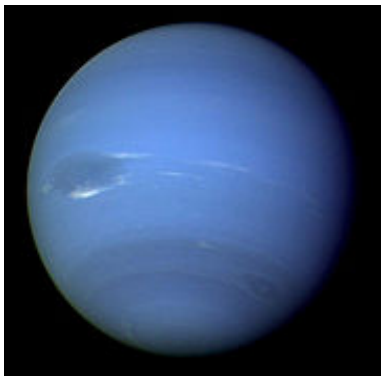

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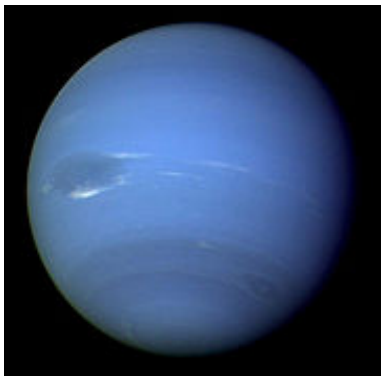

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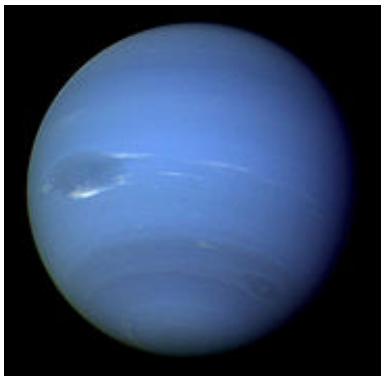

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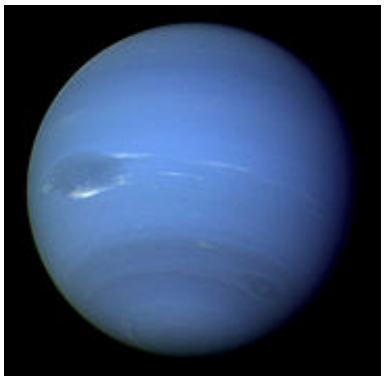

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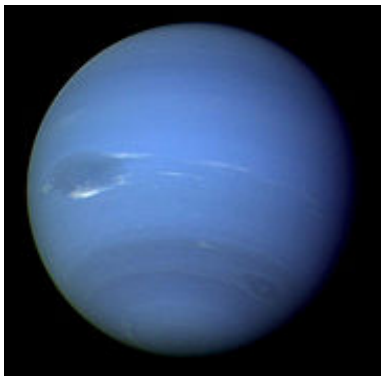

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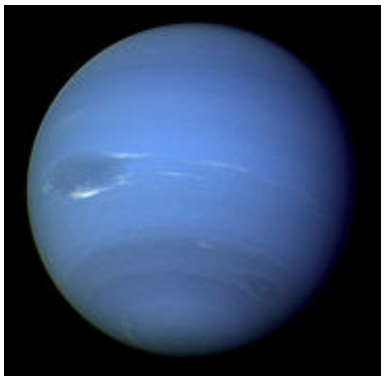

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Discovery of Neptune was first success of the Dark Matter concept!

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(picture based on

Star Trek)

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Non-discovery of Vulcan was first failure of the Dark Matter concept!

Anomalies = differences between theory and observations
Prominent examples:

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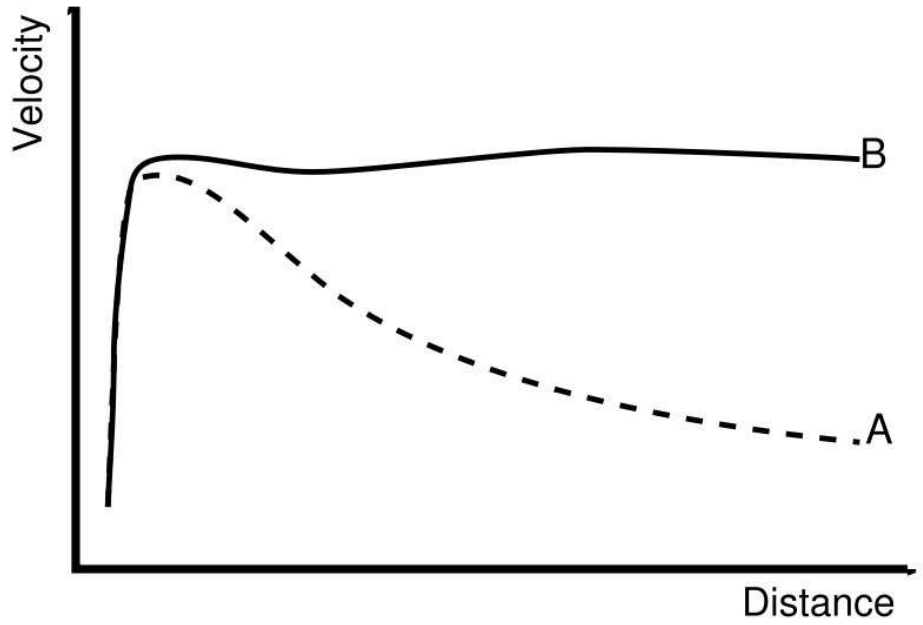
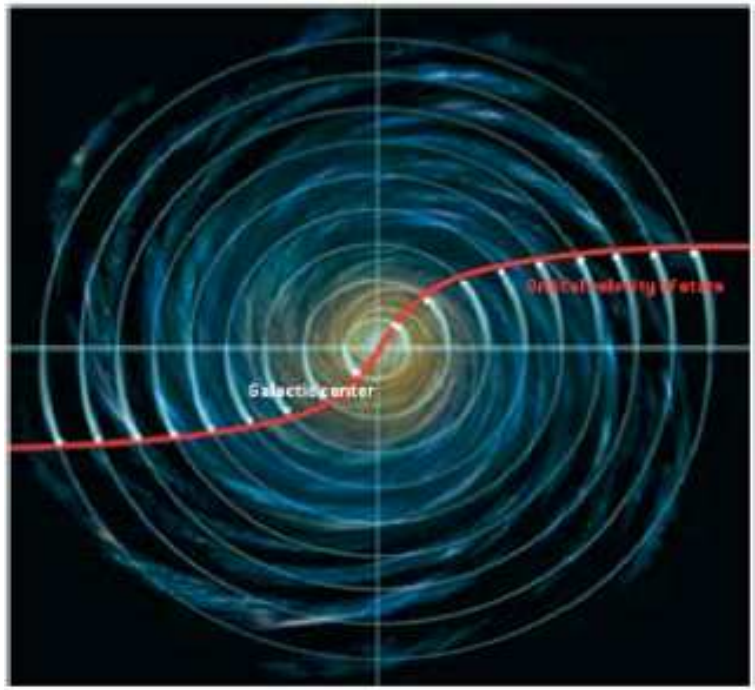
- Galactic rotation curves (pictures by Wikipedia)





A = Theory, B = Observation

Anomalies = differences between theory and observations
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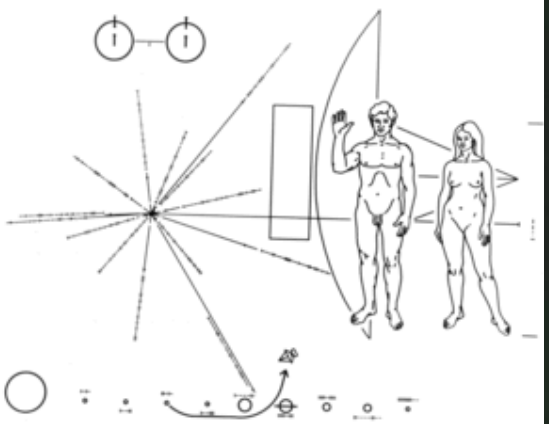
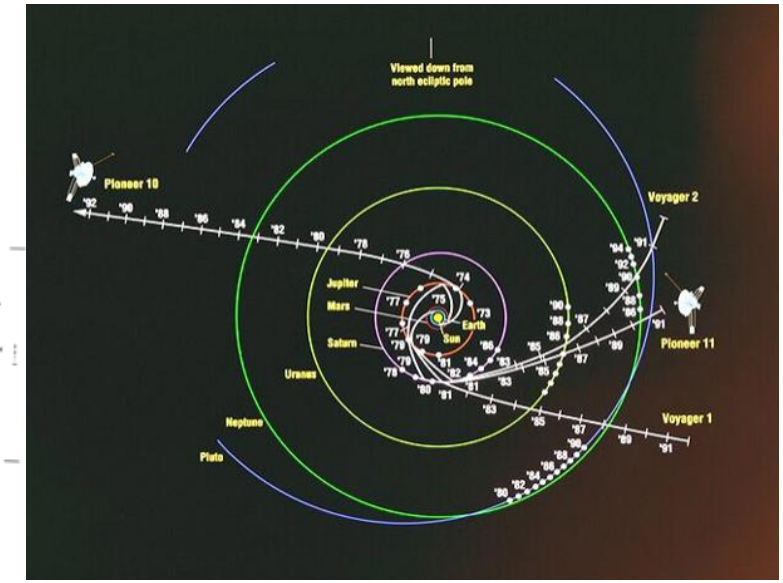
- Galactic rotation curves
- Pioneer anomaly? (pictures by NASA)





Anomalous acceleration towards the Sun?

Are we in a Neptune or a Vulcan scenario?

What is Dark Matter?

Some crucial facts about the Dark Side of life:

- Fact 1: Vulcan scenario seems unlikely for Dark Matter, but cannot be excluded

MOND, TeVeS, modified theories of gravity, ...

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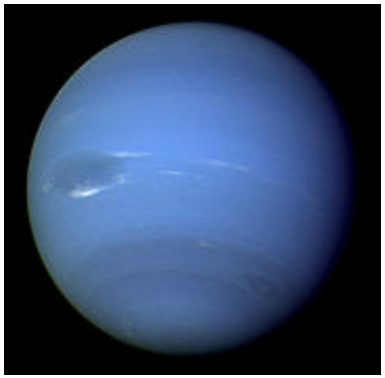

LSP, axion, WIMP, MACHO, ELKO, ...

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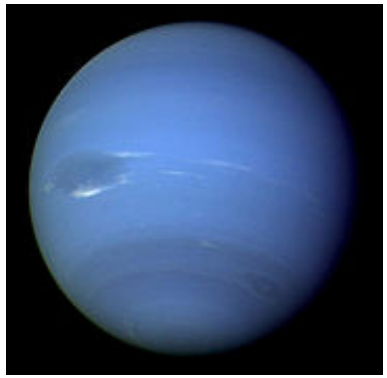

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- Show that Vulcan scenario is correct
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Both strategies are currently out of reach!

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My strategy: remain agnostic and rephrase the question

Gravity at large distances

Key question:

> What is the most general effective theory of gravity at large distances that can possibly exist?

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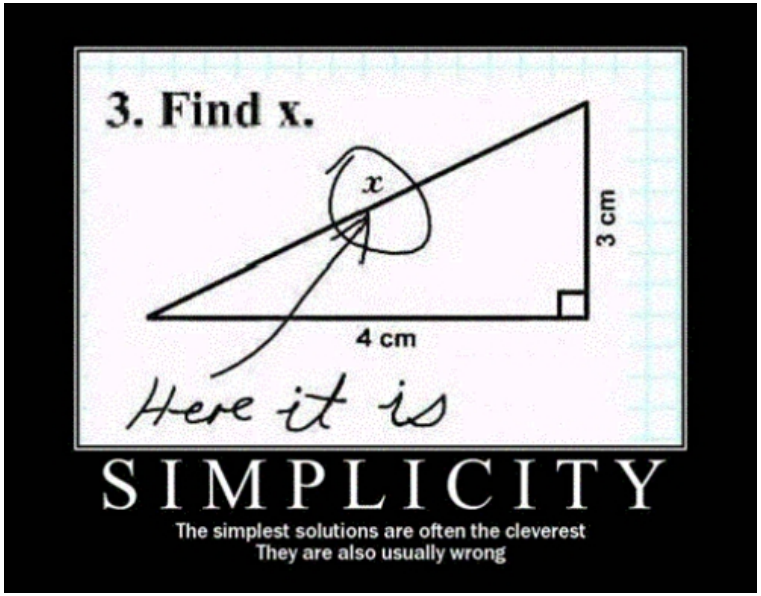

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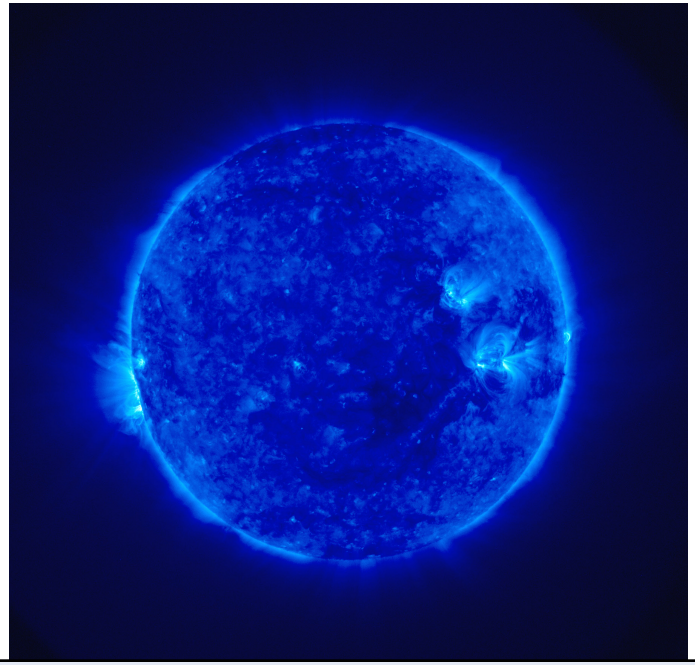

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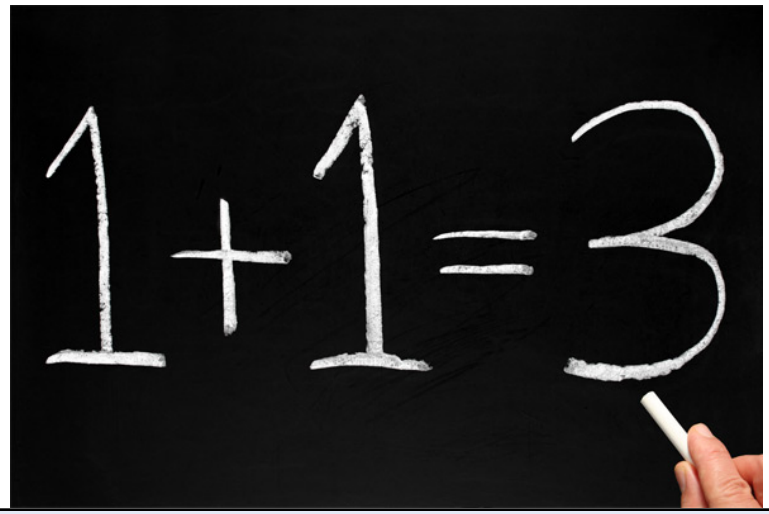

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Output: (if you are offended by mathematics just ignore the formula)

Force = Newton

$$F/m = -M/r^2$$

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$$F/m = -M/r^2 + \ell^2/r^3 - 3M\ell^2/r^4 + \Lambda r - a\,(1 - \ell^2/r^2)$$

New force arises in this model!

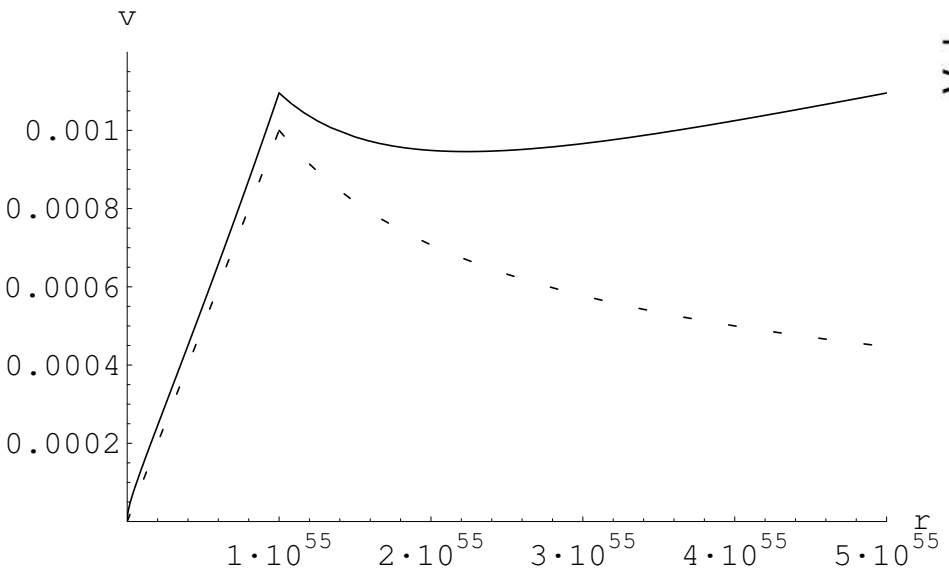
New force at large distances

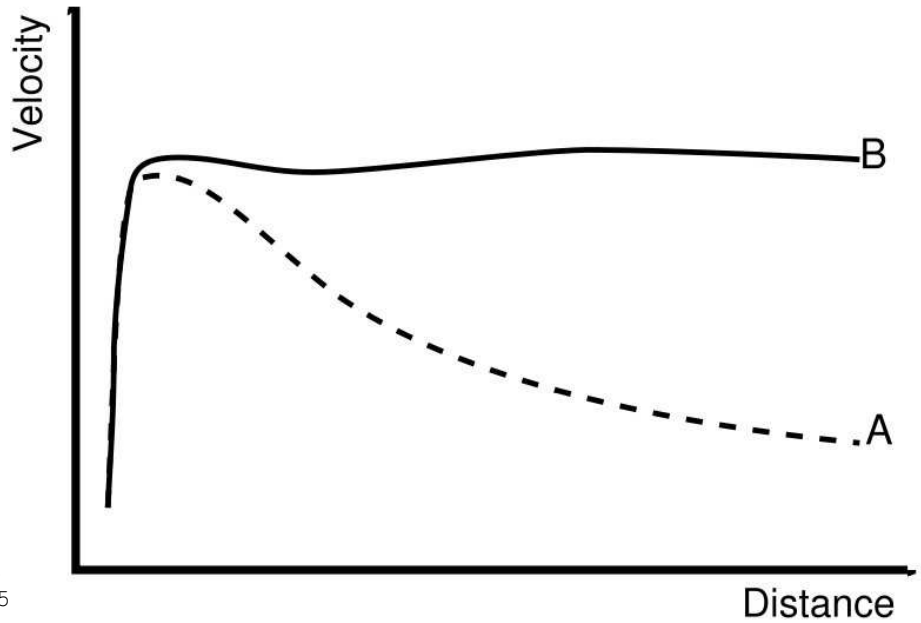
Test this for galaxies

Choose some value for Rindler force a:

$$F/m = -M/r^2 - a$$

Result for velocity profile:





Note: a is positive!

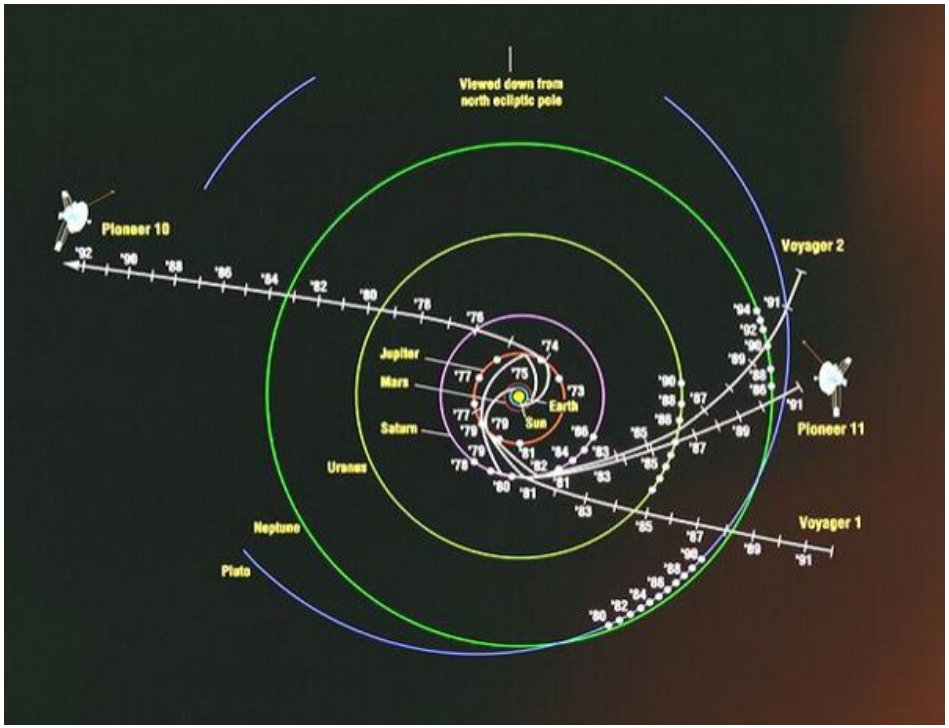
New force at large distances

Test this for Pioneer anomaly

Choose some value for Rindler force a:

$$F/m = -M/r^2 - a$$

Matches perfectly the Pioneer trajectory!



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Scientific conclusions:

- Constructed simple model for gravity at large distances
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... this may shed light on the original question.