Difference in scale

The formula used is a=G\*(m[other object]/r^2) with x += [cur\_speed]\*s + 0.5\*[cur\_acc]^t (and xpeed+=a\*t)

The problem with this is that at close distances [r] get close to zero, making [a] explode.

To resolve this, the acceleration is limited based on a maximum acceleration value each second of simulation [t]

It is possible to create a solar system and galaxy at the same time.

However, the time scale is completely different.

To resolve this, [t] has to depend on how close the objects are to each other.

However, we don't want [t] to change as one object gets closer to the other, because that would ruin the simulation.

There are 2 solutions for this:

1 - make groups of objects that are close to each other and give them the same timescale [t].

2 - use the mass of the objects to determine the timescale.

This has the advantage that e.g. the moon orbits can be calculated more precise, but we need to compensate

the orbital velocity for the "time-delay" in order to match the time it takes for one orbit around the planet.

We have chosen for solution 1:

- When an object is created, determine to what solarsystem it belongs:

Some distances: mars-phobos : 9377 km, sun-pluto: 5906400000 km

If there is an object closer than 100000000000 km, it is added to that solarsystem.

If that object does not belong to a solarsystem, it is created and both become a member.

Preset objects become a solarsystem by default.

- The group has its own total mass, speed and acceleration and is seen as one "object" on a higher scale.

By default it has no speed, but you can change the speed at the solarsystem settings.

Only exception is the preset milky way with solar system: this solarsystem has already a speed to match the milky way's rotational speed.

- When calculating the acceleration, the time [t] is based on the speed setting, but different for solarsystems and non-solarsystems (galaxy mode).

In galaxy mode [t] is multiplied by a certain number to match times that fit with galaxy rotation,

Milky way: rotates 1 time in 250 million years

Solar system:

acceleration for a solar system is only calculated for other objects belonging to that solarsystem.

acceleration for all other objects is only calculated for non-solarsystems and solarsystem as a whole.

- When changing the scale, the time is displayed as "solar system time" or "galaxy time", depending on the scale.

Limitation on Acceleration

When object are very close, the acceleration can become huge using the standard graviational formula.

To prevent this, we need to limit the acceleration.

This limitation depends on:

- the distance between the objects

- the amount of seconds used for a calculation (when the amount of seconds is high, extreme acceleration has more effect)

- objects like a moon are very close to their host, but must be allowed to be accelerated a lot, so they can stay with their host.

this can be detected in several ways:

1. overall acceleration stays the same for moon orbiting their host.

2. their movement is perpendicular to their acceleration.

3. their direction changes no more than (let's say) 20 degrees at each calculation.

We choose to make the allowed acceleration proportial to the angle between the movement direction and the graviational pull.

Calculating rotation

Because the rotational speed is usually too high (the earth makes 365 rotations in one orbit),

we allow a maximum rotational speed that is just visble by the user.

With every calculation step, we calculate the force acting on all the points that the shape consists of.

Then we calculate the part of that force, perpendicular to the point-to-center axis.

We add all those perpendicular forces, to obtain the resulting force (positive is clockwise, negative is counter-clockwise)

This force gives the rotation a certain acceleration.

Pre-calculation

When pressing the record button, a worker thread starts to calculated values for each frame. When all frames are recorded, the calculation ends.

When there are recorded frames, they are played instead of the real-time simulation.

When pressing the stop button, no more calculations are added, but the current collection is played. Resuming adds new calculations.

Each recording is one frame. There are about 25 frames per second needed.

At real-time, usually the maximum number of calculation that can be performed within a frame is made. With pre-calculation, the number of calculations is fixed with a multiplication factor for solar systems, as they usually contain less objects and circle faster.

When there are some recorded frames, the Play button plays the frames instead of realtime.