New Definition of the Astronomical Unit

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Old Definition

- Officially since 1938 (unofficially since the 19th century):

  Astronomical unit of length is such that the Newtonian gravitational constant G is equal to the square of the Gaussian constant k

  $$G = k^2 = 0.000\ 295\ 912\ 208\ 285\ 591\ 102\ 5$$

  provided that the mass of the Sun and the day (86400 SI seconds) are taken as the units of mass and time, respectively.

  The Gaussian constant $k = 0.017\ 202\ 098\ 95$ is a defining constant.

- Concept similar to other cases when a unit is defined indirectly by fixed values of some natural constants (e.g. $G = c = \hbar = 1$ for the geometrized units)

- Allows to compute angular positions of solar system bodies without precise knowledge of their distances. In the past, the former were known with much higher accuracy than the latter.

- The length of astronomical unit in Système International (SI) meters depends on the theory of motion and observations being used.

New definition of astronomical unit

- A new definition of astronomical unit of length (au) proposed in 2012:

  The astronomical unit (au) is a conventional unit of length equal to a fixed number of SI meters:

  1 au = 149 597 870 700 m (exactly)

- Why: BCRS distances between solar system bodies now known very well (often much better than the angular directions to the bodies) so no need to decouple angular positions and distances

- Numerical value of the new definition chosen to be consistent with the best estimate corresponding to the old definition.

- Further advantages:
  - Eliminates deviation from SI
  - Eliminates dependence on theory of motion
  - Provides a self-consistent set of units in the relativistic framework
  - Avoids time-dependent units if time variation of solar mass is considered
  - Permits direct determination of time variation in solar mass parameter GM_{Sun} in SI units

Impacts

- Mainly concerns those in the field of high-accuracy solar system dynamics.

- Although astronomical unit defines parsec and thus the whole astronomical distance ladder, the relative difference between the old and the new definitions will not exceed 10^{-10} , so no significant effect considering relative errors of cosmic distances outside solar system.