The Origin of the Moon Seen through an Isotopic Lense

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For many years, the prevailing view was that the Moon was formed by the impact of a Mars-size embryo with the proto-Earth at a velocity just above the mutual escape velocity [1]. This scenario, which came to be called the "canonical model" of lunar formation, can explain the angular momentum of the Earth-Moon system and the small mass of the lunar core. However, high precision isotopic analyses of lunar rocks have shaken the foundations of the canonical model, leading to the development of alternative scenarios such as (i) formation of the Moon from a synestia structure in the aftermath of the collision between a fast spinning protoEarth and a high-velocity impactor [2,3]; (ii) collision between 2 half-Earth size planetary objects [4]; (iii) formation of the Moon by accretion in a circumterrestrial orbit by multiple impact ejections [5]; (iv) accretion of the Moon by collision with impactors stored in one of the Lagrange points [6], or (v) Earth-Moon isotopic equilibration [7]. The main motivation for most of these models is the claim that the canonical model cannot explain the Earth-Moon isotopic similarity for elements that carry isotopic anomalies such as ^{17}O and ^{50}Ti, or radiogenic ^{182}W [8 and references therein]. The case was also made that the canonical model of lunar formation could also not explain the observed heavy K isotope enrichment of lunar rocks relative to terrestrial rocks [9]. I will review existing constraints on isotopic anomalies and ^{182}W to assess whether isotopes have falsified the canonical model. I will also re-evaluate interpretations of lunar K isotope data in light of our new *ab initio* calculations of vapor-solid equilibrium fractionation as well as theoretical considerations on kinetic isotopic fractionation associated with condensation.

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