Different arrival times from the outer solar system of CI and CM-like bodies in the asteroid belt

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The Solar System's current compositional distribution belies the primordial disk's original makeup due to the dynamical reshuffling over 4.5 billion years. Understanding the provenance of the most primitive materials in our meteorite collections (CI and CM chondrites) is not only important for our comprehension of the early evolution of the Solar System but also for providing the context of recent sample return missions. As of today, there is a general consensus that these materials originate from beyond Jupiter based on isotopic measurements, but their respective formation locations remain elusive. Here, we show that the parent bodies of these two meteorite groups have distinct distributions in the asteroid belt, indicating either two distinct formation areas or two distinct formation times. We use N-body simulations to simulate the effect of giant planet growth and investigate the dynamical evolution of small bodies formed beyond Jupiter and up to Neptune when gas was still present in the disk ($\leq$5 Myrs after CAIs). We find that pressure bumps in the disk predominantly trap small bodies irrespective of their formation zone, resulting in the gas disk profile entirely governing the radial distribution of implanted bodies in the asteroid belt. CI and CM-like bodies must have been implanted at different times in the belt whereas CI and comet-like bodies were implanted at the same time, as the correlation between these two distributions has a $P > 0.05$. We find that CM-like bodies were likely implanted during Saturn's growth whereas CI and comet-like bodies were likely implanted from the region beyond Uranus at a later stage, during the outward migration of Uranus and Neptune. It follows that chondrule formation occurred mostly inward of the ice giant's formation zone ($\leq$10 AU). A byproduct of our simulations is that CM-like bodies contributed to the water budget of the formation region of telluric planets. Our findings also underscore the influence of gas properties and the growth of giant planets on the system's evolution, which leads to biases in dymaical models.