CONNECTING PEBBBLE ACCRETION TO CHONDRULES. M. Lambrechts[1] and A. Morbidelli[2] and A. Johansen[3], [1]Observatoire de la Côte d'Azur (michiel.lambrechts@gmail.com), [2]Observatoire de la Côte d'Azur (morby@oca.eu), [3]Lund Observatory (anders@astro.lu.se).

Introduction: In the outer parts of protoplanetary discs, icy particles coagulate efficiently up until they reach larger-than-mm sizes [1]. Then, because of gas drag, these pebbles start drifting inwards [2]. Previous work has argued that embryos can efficiently sweep up pebbles from this radial pebble flux [3]. When pebbles enter the region of gravitational influence of the core (the Hill sphere), the crossing time is comparable to the friction time scale, which results in accretion [4,3]. Planetesimals, that feel less drag, easily have have 100 times smaller accretion cross sections. In this way, pebbles provide gas-giant cores the mass growth needed to complete formation before gas disc dissipation, even in wide orbits [3,5,6].

Inner disc: This scenario (Fig.1) also has implications on the growth of bodies in the inner solar system. Inside the ice line, ice sublimation, bouncing and fragmentation lead to smaller pebbles, likely of chondrule-size [7]. The mass in small particles delivered in this fashion to the inner disc may exceed tens of Earth masses [3]. This radial pebble flow only comes to a halt when the core of Jupiter reaches completion and perturbs the gas disc in such a way that a pressure bump traps incoming particles [8].

From Chondrules To Embryos: In this talk, we will focus on the role of such pebbles in the terrestrial planet forming region. Small sedimenting particles may concentrate on small scales to form dense regions ideal for chondrule formation [9]. In the midplane, pebbles can participate in streaming instabilities [10,11]. Recent work has shown that even chondrule-sized particles can trigger this instability [12]. The pebble densities obtained in this way allow for planetesimal formation by direct gravitational collapse. The largest planetesimals can grow efficiently to embryo sizes by sweeping up chondrule-sized particles.

We will present new work that focusses in detail on planetesimal-to-embryo growth. This critical growth stage is modelled with the help of a particle-in-a-box code that treats collisional growth, fragmentation, dynamical stirring and damping [13]. Additionally, we include pebble accretion on bodies with possibly eccentric and inclined orbits. Like the study by Johansen et al, we start with an initial population of planetesimals formed by the streaming instability [14].

From comparison with the size distributions of the minor bodies in the Solar System (asteroids and Kuiper belt objects), we can place constraints on conditions in the Solar Nebula. We also find that our model argues for a relatively late formation of a pre-depletion asteroid belt that is about 100 times more massive than the current asteroid belt.

Finally, we can illustrate why growth proceeds slower in the inner disc compared to the outer solar system. This provides an explanation for the embryo dichotomy [15]: cores in the outer Solar System grew large, but embryos in the terrestrial zone did not exceed Mars in mass.

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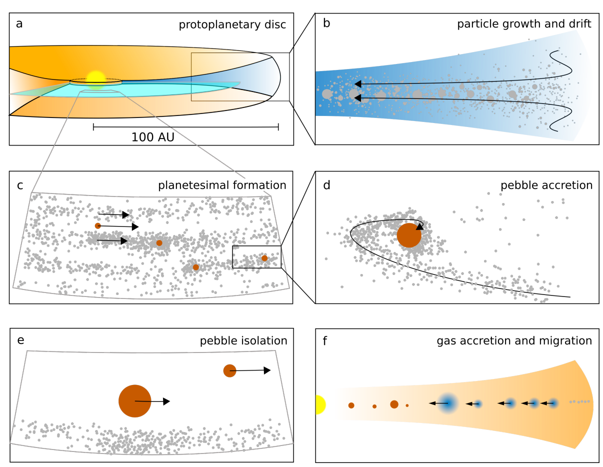

Figure 1 In a protoplanetary disc (a), pebbles grow and drift inwards (b). In dense pebble swarms, planetesimals form by self-gravity (c) and the largest accrete pebbles efficiently (d) until they reach isolation (e). Subsequently, planetary migration and gas accretion proceed until disc dissipation (f).