Highlights of 2023 – DNRF Chair Anders Johansen

I describe here three highlights from my research as DNRF Chair in 2023.

Breakthrough in our understanding of how Earth formed
Onyett, I. J.; Schiller, M.; Makhatadze, G. V.; Deng, Z.; **Johansen, A.**; Bizzarro, M., "Silicon isotope constraints on terrestrial planet accretion", 2023, Nature, 619, 539-544
In this Nature paper we compared, for the first time, the composition of silicon isotopes in various meteorite classes to the composition of Earth. Meteorites are fragments of asteroids that land on Earth; they can therefore be used to directly measure the composition of minor bodies in both the inner and the outer Solar System. I worked together with the cosmochemistry group at the Globe Institute to interpret the implications for planet formation. We reported that Earth formed by a mixture of approximately 70% material from the inner Solar System and 30% material from the outer Solar System. This measure supports our novel model from Johansen et al. (2021) where we proposed that Earth formed rapidly (in only a few million years) by accreting small pebbles that drift towards the young star.

The first connection between planet formation and the primordial atmosphere
Johansen, A.; Ronnet, T.; Schiller, M.; Deng, Z.; Bizzarro, M., "Anatomy of rocky planets formed by rapid pebble accretion. I. How icy pebbles determine the core fraction and FeO contents", 2023, Astronomy & Astrophysics, 671, A74
Johansen, A.; Ronnet, T.; Schiller, M.; Deng, Z.; Bizzarro, M., "Anatomy of rocky planets formed by rapid pebble accretion. II. Differentiation by accretion energy and thermal blanketing", 2023, Astronomy & Astrophysics, 671, A75
Johansen, A.; Ronnet, T.; Schiller, M.; Deng, Z.; Bizzarro, M., "Anatomy of rocky planets formed by rapid pebble accretion. III. Partitioning of volatiles between planetary core, mantle, and atmosphere", 2023, Astronomy & Astrophysics, 671, A76

I published a series of three papers in Astronomy & Astrophysics about the composition, differentiation and atmospheric outgassing of planets that form by rapid pebble accretion. This work constitutes one of the main goals in the scientific plan for the DNRF Chair. I showed that the rapid formation of Earth is consistent with the timing of core formation for our planet, based on the radioactive decay system where ^{182}Hf decays of ^{182}W with a half-life of 8.9 million years, if the giant impact that formed our Moon happened at least 35 million years after the main accretion phase of Earth. I also explained the difference between the atmospheres of Earth, Venus and Mars. Mars outgassed an atmosphere of H_2 and CO from its magma ocean and lost these molecules to space, while Earth and Venus outgassed an atmosphere with CO_2 and H_2O. Most of the CO_2 on Earth was later buried in the mantle.

Awarded the scientific prize "NCU-DELTA Young Astronomer Lectureship Award"
https://www.astro.ncu.edu.tw/ncu_delta/index.php
https://www.astro.ncu.edu.tw/ncu_delta/reciNews.php?id=16
I received the "Young Astronomer Award 2023" from the Delta Foundation in Taiwan. Delta Electronics is known for its highly efficient computer fans and power supplies. Its founder, Bruce C. H. Cheng, has an interest in both clean technologies and astronomy. I went to Taiwan for two weeks in March 2024 to receive the award and give lectures to the Delta Foundation in Taipei, to a high school class in Taichung and at three Taiwanese universities.