Many (all) the questions have been answered during the Q&A period. Nevertheless, we ask that you provide written answers below so students can come back to read them again. Thanks!

1. Are there any searches for a fundamental sterile massive DM particle, i.e. no weak coupling, only mass coupling.

2. if DM is of particle nature but interacts only gravitationally, are there ways to directly detect DM? gravitational waves experiments ?

   (The above questions answered together:)

   If DM doesn't interact except gravitationally, it will be hard to learn its fundamental nature, but there are some things we can learn.
   Firstly, self-interactions or dark sector interactions influence what we see in astrophysical systems. For example, self-interactions vs no self interactions can give very different predictions for how cuspy the dark matter profile is in galaxies.

   We can also do things like gravitational lensing to get some sense of its structure, which also might tell us about how it interacts in some dark sector.

   Overall though, in that case generally we're restricted to (i) how it interacts with itself or within a dark sector, or (ii) how it interacts gravitationally.

3. I have a very general question. Which type of Atomic DM model can best explain the large scale structure? and how do these different models contribute to our understanding to large scale structure?

   I'm not sure which version of "atomic" you mean, so I can answer it both ways:
   1. You can have DM that exists in bound states; depending on the model details these can be totally fine with large scale structure.
   2. If you're thinking baryonic matter in a bound state, one case people that thought about is the sexaquark, which has QCD charge, see this paper for example for some model details: https://arxiv.org/abs/1708.08951
   In both cases they can also help with small scale structure explanations (i.e. galactic DM core cuspyness).

4. (Page 50) Masses can be very low. Are they still non-relativistic or do they evade conclusion from structure?

The axions are ok with structure constraints, because the axion field just acts like a classical scalar field and it was never in thermal equilibrium with the SM (for light axions and therefore small couplings). If you had a thermalized particle in the early Universe, this wouldn't be ok (and then you get the ~keV or so lower bound from structure). They actually provide interesting other structure predictions like for example axion stars. More details together in the answer (6) below.

5. I have simple question for my understanding in this field, I was wondering how raw data from detector are used to get the limit plot (the plot that shows cross-sectional area Vs Mass of dark matter?

   (discussed in the experimental talk)

6. (Page 51) Why the axion, being a DM, must be oscillating to produce the relic abundance?

   If we assume the axion field starts at a particular position in the potential (it is "misaligned", which is the "misalignment angle"), it rolls towards its minimum after the QCD phase transition. But it continues to oscillate through the minimum, and the energy density stored in the field behaves like cold dark matter. Here it isn't a single cold dark matter particle, but rather a classical scalar field that permeates the Universe. Note that while the field keeps oscillating, the energy density stored in the field is rather stable and just dilutes like ordinary matter, giving the same redshift behavior.

   We want this to get the relic abundance, and not some thermal production mechanism, as above, thermal could wipe out structure at the light masses.

7. If axion is a DM, what is allowed mass range?

   If we want it to be cold dark matter with order one theta, we're looking at about 10^-8 – 10^-3 eV. But it can also be a subcomponent of DM, as hot DM, if its mass is a bit heavier (subcomponent is required because hot DM has problems with structure). To be DM generally we want stability, so for this case we want masses below about 20 eV (otherwise it decays too quickly), making axion DM quite light. There are also some experimental constraints by now, see for example the slide with the photon constraints.

8. As particle physicists, we tend to think about particles as solutions to problems. Can we be guilty of looking for nails when we have a hammer? Are there viable non-particle explanations of observations?

   So far, all we observe in nature really are particles; quantum field theory gives us quanta. So I don't think it's an unreasonable assumption that dark matter follows similar theoretical principles. There are of course other options that have been considered quite seriously in the past, such as compact objects which are not particles. They've run into strong constraints with our observations, leaving only really primordial black holes as a potential option there. There's also of course modified gravity options, but it is increasingly difficult to fit the data without also adding new particles. Of course, we should keep our minds open because we in reality know very little about dark matter, but extending our theoretical principles that seem to correspond to reality so far is a good approach.