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. (Page 10) How do we get local properties of DM halo equation form?
    a. Important information to determine DM halo properties, specifically the DM density distribution, comes from rotation curve data. The observed velocities of stars at a certain distance from the galactic center inform about the required mass of inclosed DM to uphold the respective velocities.
    b. The velocity dispersion in the DM halo is often based on the virial theorem and combined with the assumption of a Maxwell-Boltzmann distribution. Note, though, that this assumption is a simplification and significant work is put into an improved, less general description of the DM halo velocity dispersion, especially of the Milky Way halo, e.g. using cosmological simulations.

2. (Page 21) Initial phonon production comes from nuclear recoil. Do phonons from drift electrons occur through nuclear recoils as well? Is phonon production through drift only at moderate bias voltage, beyond which you get ionization from drift electrons?
    a. Both nuclear recoils and electron recoils initiate primary phonon production. Only the fraction of energy that goes into the creation of e/h pairs differs for nuclear recoils vs electron recoils for the same amount of deposited energy.
    b. On the contrary. At moderate voltages (few V) the NTL effect (the production of secondary phonons) doesn't contribute significantly. One needs higher voltages (at least O(10V)) to get a notable amount of secondary phonons. And the higher the voltage the larger the amount of secondary phonons. Note that also at these higher voltages no avalanche process in terms of ionization production is started as would be the case in e.g. proportional counters. The charges don't reach high enough velocities as they don't reach the maximum possible velocity given the electric field. Instead they dissipate their excess energy in the form of secondary (i.e. NTL) phonons.

3. (Page 42) Is it correct to conclude that if we see a signal here, there is no information on DM mass?
    a. While it is true that the typical energy transfer is largely determined by the electron, not by the DM mass, the spectral rate is not exclusively determined by the electron. The DM mass still has an impact on the spectral shape, just to a much lesser extent than in the case of DM-nucleus scattering.

4. (Page 52) What are the freeze-in and free-out bands? Are they the equivalent of neutrino floor where some background dominates? And what is the wiggle around 250 MeV in the right figure?
    a. These bands are not background predictions but theory DM predictions given the expected relic DM density of a certain model at a certain DM mass and cross section. They are also referred to as “relic target” or “relic DM abundance” and experimentally probing these targets will be very important to exclude DM models or to potentially confirm a model which means to discover DM.
    b. Wiggles like that come from resonances of the new mediator (e.g. the dark photon) with SM particles with appropriate quantum numbers for the new mediator to couple to it (e.g. the Z boson). Hitting such a resonance significantly alters the interaction rate between DM and SM particles and thus the resulting expected DM abundance. The location of the wiggle depends on the respective SM particle and the mass of the mediator that is in resonance with that SM particle. For the shown relic target a mediator mass of three times the DM mass (m_DM ~= 350 MeV) was assumed, i.e. m_A’ ~= 1 GeV. So it is very likely the phi(1020) resonance (with a mass of ~1.020 GeV), though I could not trace back the source of the shown relic target. But the real take home message is the first sentence of this answer.

5. (Page 52) In this page two results corresponding to freeze-in and freeze-out are shown given by different expressions of the F-factors. Are they just choices by hand? Or is the F-factor for freeze-out always 1?
    a. The relic targets (freeze-in / freeze-out) and whether the new mediator is ultra-light or heavy are directly related. E.g. in the case of an ultra-light mediator the couplings are too small for the DM to have thermalized with the SM sector and freeze-out would not have been possible. I want to add, though, that for a given mediator assumption, different DM models exist resulting in different relic targets. I would thus rather invert the question

    and ask whether for e.g. a DM form factor of 1 the only target is that of DM with freeze-out abundance. The answer in this case is no. This is one highly interesting and well-motivated relic target, but not the only one.

6. (Page 52) How to derive the F-factor given in figure for freeze-in case?
    a. Generally speaking the DM form factor F_DM is a way to separate the q-dependent part from the matrix element of the DM-electron scattering interaction (q: momentum transfer). The momentum space matrix element is M(q-vector) and F_DM is defined such that \bar{ |M(q-vec)|^2 } = \bar{ |M(alpha * m_e)|^2 } x |F_DM(q)|^2 where m_e is the electron mass and alpha is the fine structure constant. The “bar” indicates that the absolute and squared values of the matrix elements are averaged over their initial spins and they are also summed over the final particle spins. So if you want to derive the form factor, you turn the whole thing around and calculate |F_DM(q)|^2 = \bar{ |M(q-vec)|^2 } / |M(alpha * m_e)|^2 }. Note that the electron moves at a speed of alpha. So alpha*m_e is the electron momentum and M(alpha*m_e) is the matrix element of DM-electron free elastic scattering.

7. (Page 74) It looks like each experiment (ADMX, HAYSTAC etc) is a vertical band, meaning a limited mass range. This translates to a limited frequency range. But I thought the experiments scan frequencies?
    a. The plot is a little bit misleading in this regard because it spans nearly 20 orders of magnitude in axion mass range. If you instead zoomed in to the region around ~10^-6 to 10^-4 eV you could see that a band of masses, meaning a band of frequencies, was in fact covered by each experiment. But it is still true that the amount of accessible frequencies, and thus masses, is limited. The frequency that can be generated within a resonator cavity depends on the experimental set-up like the geometry of the cavity. And one can vary the geometry to some extent with a given set-up, e.g. by using tuning rods in the case of ADMX. But eventually the cavity size is naturally limited and thus the achievable frequency. Extending the search to lower masses, far below 10−6 eV (~250 MHz), the cavity and the magnet become unfeasibly large.

8. (Page 74) Follow-up question to real-time answer of another question. I think you said the cavities would have to be much larger to get to lower masses /

frequencies. Does this mean this technique has pretty much hit its limit in terms of mA?

a. That is correct. To circumvent these limitations, approaches different from microwave cavities are being pursued. The DM Radio experiment for example replaces the cavity with a lumped-parameter LC circuit which is external to the magnetic field. Or alternatively one can give up on using photons in the first place and instead aim for the detection via NMR (nuclear magnetic resonance) spectroscopy as is proposed by the CASPEr experiment. Either way it is important to explore new approaches to be able to cover the full axion / ALP / dark photon space that is well-motivated for wave-like dark matter. Microwave cavities are not able to do so alone.