Looking at the axionic dark sector with ANITA

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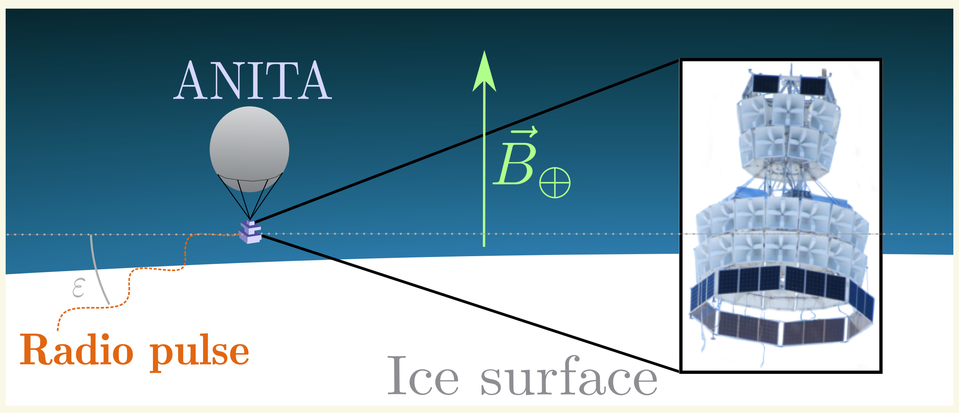
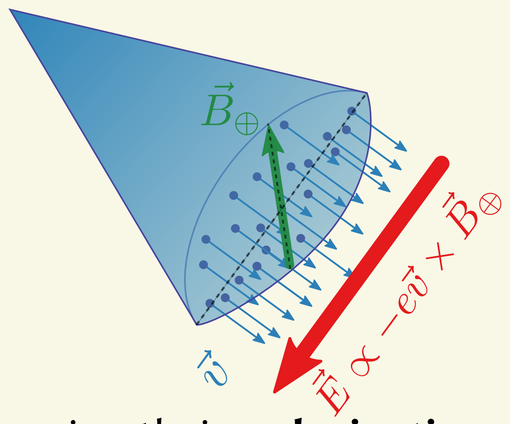
ANITA



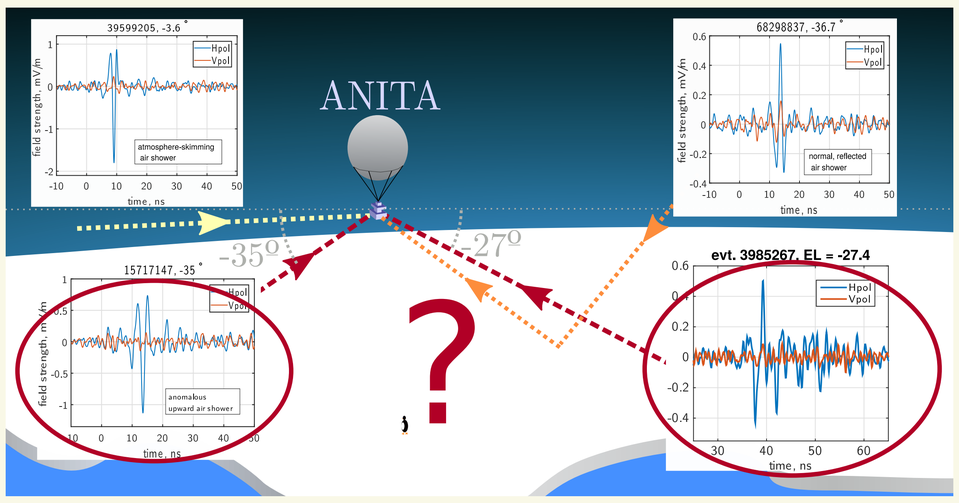
- It can detect cosmic rays!
- Cosmic ray pulses are
  1. Polarized $\perp$ to $\vec{B}_\oplus$ ($\sim$ **horizontally**)
  2. Well-defined phase (**changes at reflection**)



ANITA identifies cosmic rays measuring their **polarization**. Their **phase** tells if they are direct or reflected.

What are these up-going events?!

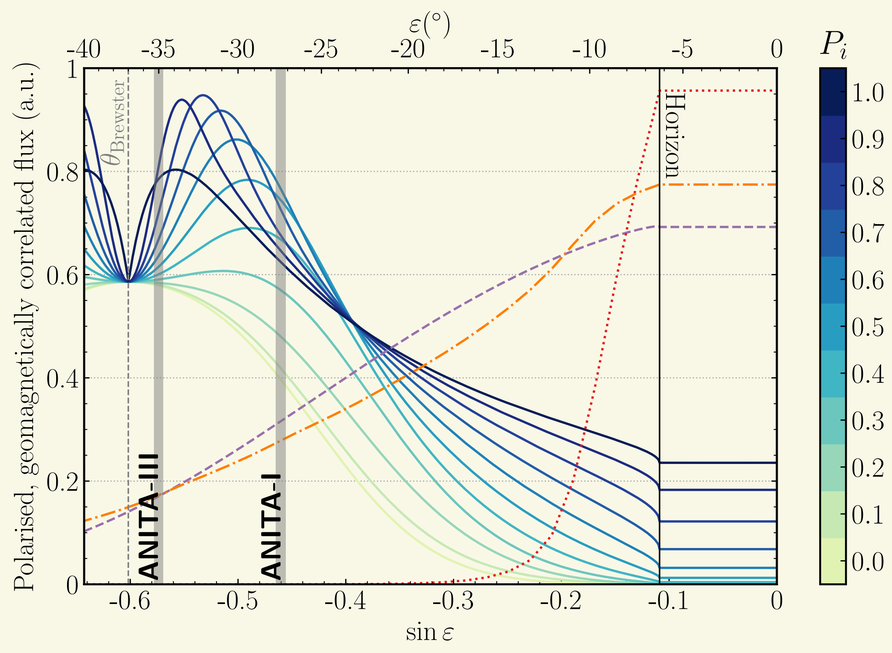
ANITA has observed two anomalous cosmic ray-like events: direct, but up-going! (From $\sim -27°$ and $\sim -35°$ below the horizon)



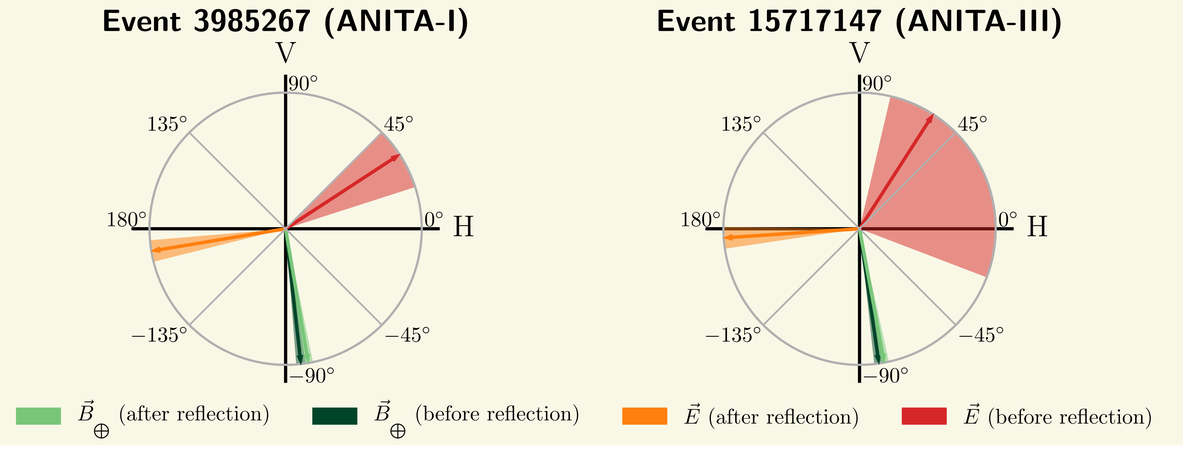
- SM: an $\sim \mathcal{O}$(EeV) neutrino is in tension with ANITA, IceCube and Auger[3].
- BSM: a high-energy shower is in tension with IceCube and Auger[3].

The observed events are $\sim$ horizontally polarized, and **a reflected radio pulse also tends to be horizontally polarized!**

What if they are reflected? Flux of reflected events $\perp \vec{B}_\oplus$



What if they are reflected? Polarization



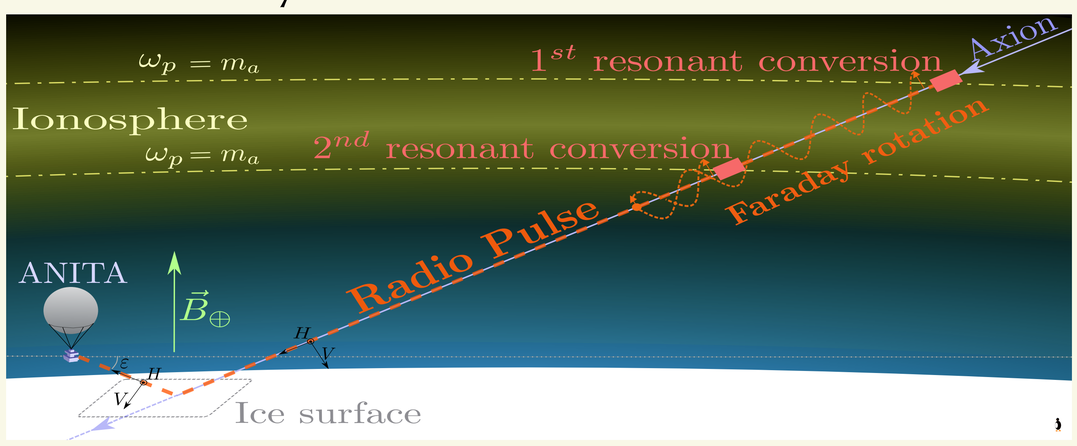
Axions: resonating in the ionosphere

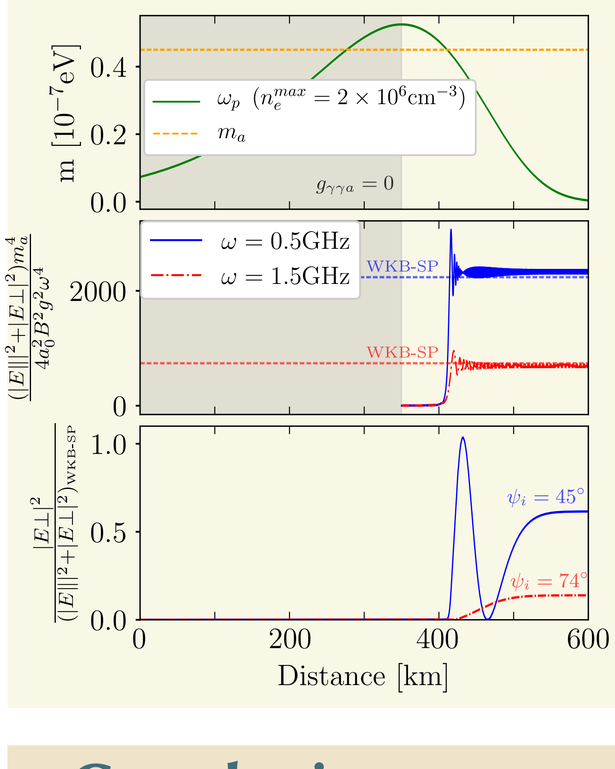
The axionic dark sector can be rather complex: boson stars, "bosenovas"... If an ALP burst reaches us, it transforms into photons in the Earth magnetic field

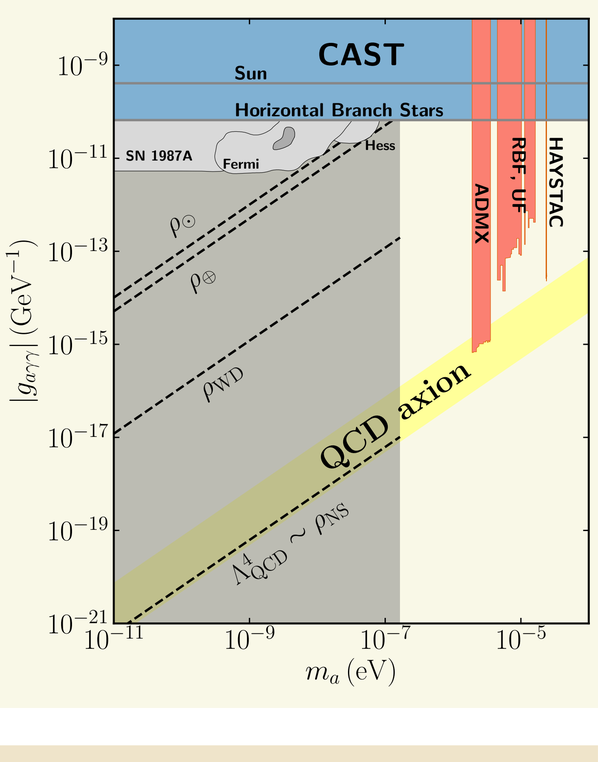
$$\left[\partial_z^2+\omega^2+\begin{pmatrix} -\omega_p^2 & -i\omega_p^2\frac{\Omega_z}{\omega} & 0 \\ i\omega_p^2\frac{\Omega_z}{\omega} & -\omega_p^2 & -g_{a\gamma\gamma}B_y^\oplus\omega^2 \\ 0 & -g_{a\gamma\gamma}B_y^\oplus & -m_a^2 \end{pmatrix}\right]\begin{pmatrix} E_x \\ E_y \\ a \end{pmatrix}=0\,,$$

For ANITA frequencies $\sim$ GHz, in the ionosphere:

- $\omega_p = m_a \lesssim 10^{-7}\,\text{eV} \Longrightarrow$ resonant conversion
- Faraday effect: initial polarization, $\| \vec{B}_\oplus$, can rotate to the one observed by ANITA







Conclusions

- An isotropic, linearly polarized flux of radio pulses can generate ANITA's anomalous events via reflection close to θ_{Brewster}, explaining their *directionality* and *polarization state*.
- This flux can be resonantly produced in the ionosphere via the interaction of an ALP burst with the Earth magnetic field:
  - No bounds from IceCube and Auger, since this involves very soft physics $\sim \mathcal{O}(10^{-7}\,\text{eV})$.
  - Very predictive and **readily testable scenario**: non-horizontal events far from θ_{Brewster}, and doubled events with lower coherence are predicted.

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[1] P. W. Gorham *et al.* [ANITA Collaboration], Phys. Rev. Lett. **121** (2018) no.16, 161102 [arXiv:1803.05088 [astro-ph.HE]].
[2] P. W. Gorham *et al.* [ANITA Collaboration], Phys. Rev. Lett. **117** (2016) no.7, 071101 [arXiv:1603.05218 [astro-ph.HE]].
[3] J. M. Cline, C. Gross and W. Xue, arXiv:1904.13396 [hep-ph].

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