

## INTRODUCTION

Altermagnets are collinear compensated magnets in which opposite-spin sublattices are related by crystal point-group symmetries, such as rotations or mirrors, leading to momentum-dependent spin splitting even in the absence of spin-orbit coupling, while maintaining zero net magnetization. CrSb (NiAs-type,  $P6_3/mmc$ ,  $T_N \sim 700$  K) has emerged as a prototypical metallic  $g$ -wave altermagnet, with spin splitting in the electronic bands confirmed by ARPES [2, 3]. The analogous splitting in the magnon spectrum — a complementary collective-mode signature — has only very recently been reported [1, 4].

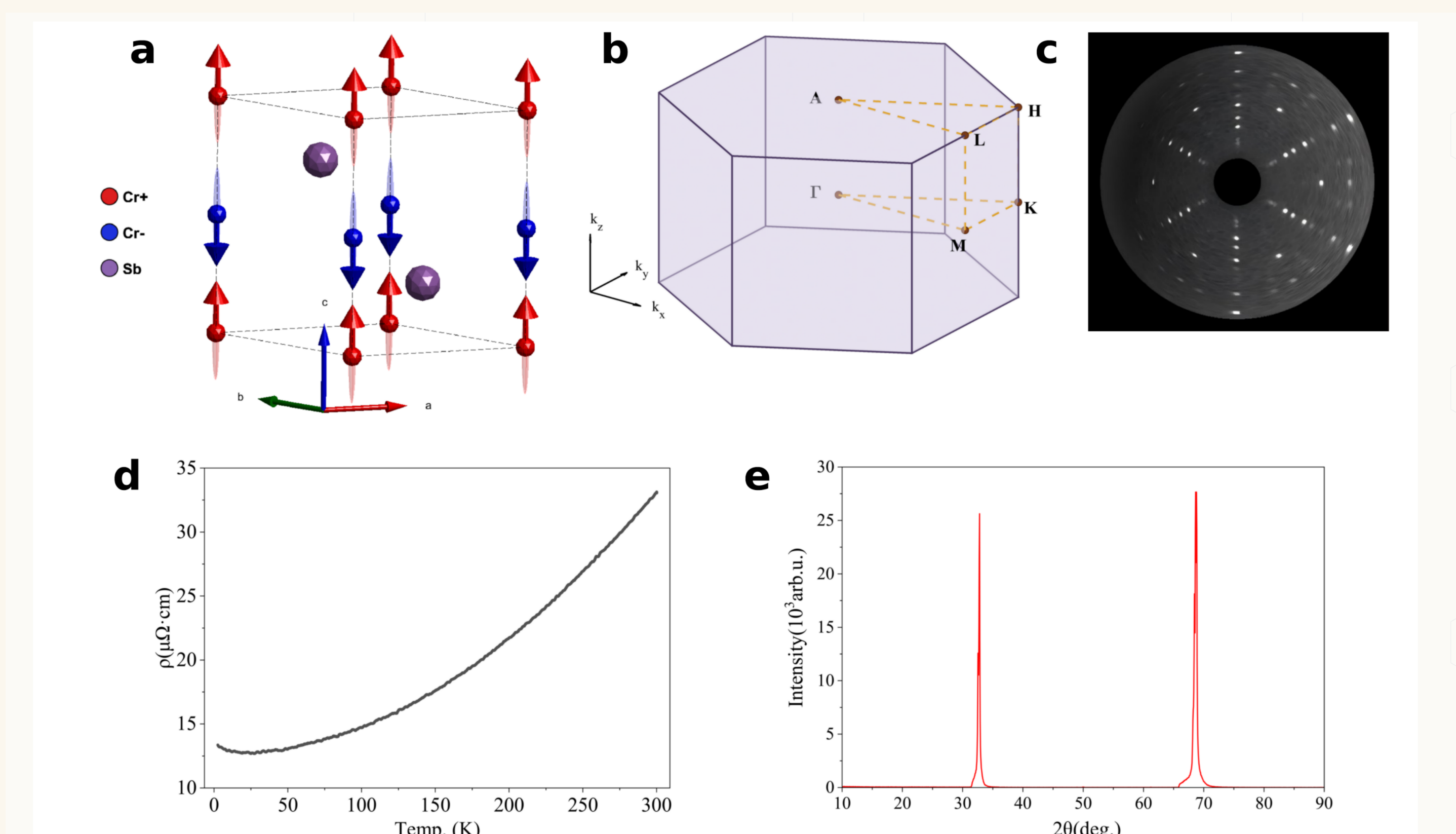
Here we use high-resolution time-of-flight inelastic neutron scattering on co-aligned CrSb single crystals to characterize the magnon dispersion in the HK0 reciprocal-space plane and along the A–M high-symmetry direction. A minimal Heisenberg model quantitatively reproduces (i) an energy-dependent splitting of the magnon arc that grows monotonically from 0.030 to 0.105 r.l.u. between 165 and 215 meV; (ii) a two-peak structure resolved along A–M, further confirming the altermagnetic magnon splitting; and (iii) the absence of splitting along the symmetry-degenerate (H,  $-2H$ , 0) direction, providing an independent symmetry-based confirmation of the altermagnetic model.

## METHODS

CrSb single crystals were prepared and characterized for high crystal quality (Fig. 1c–e). Inelastic neutron scattering measurements were performed on the ARCS time-of-flight chopper spectrometer at the Spallation Neutron Source, Oak Ridge National Laboratory, on  $\sim 20$  g of co-aligned single crystals with a mosaic spread of less than  $2^\circ$ , using an incident neutron energy of  $E_i = 450$  meV. Data reduction was carried out with Horace; magnon dispersion modeling and exchange-parameter fits used SpinW with a minimal 6- $J$  Heisenberg Hamiltonian (Cr  $S = 3/2$  spins) including intra- and inter-sublattice exchanges. Constant-energy slices were averaged over symmetry-equivalent zones via the  $C_3$  rotation in reciprocal space to improve statistics.

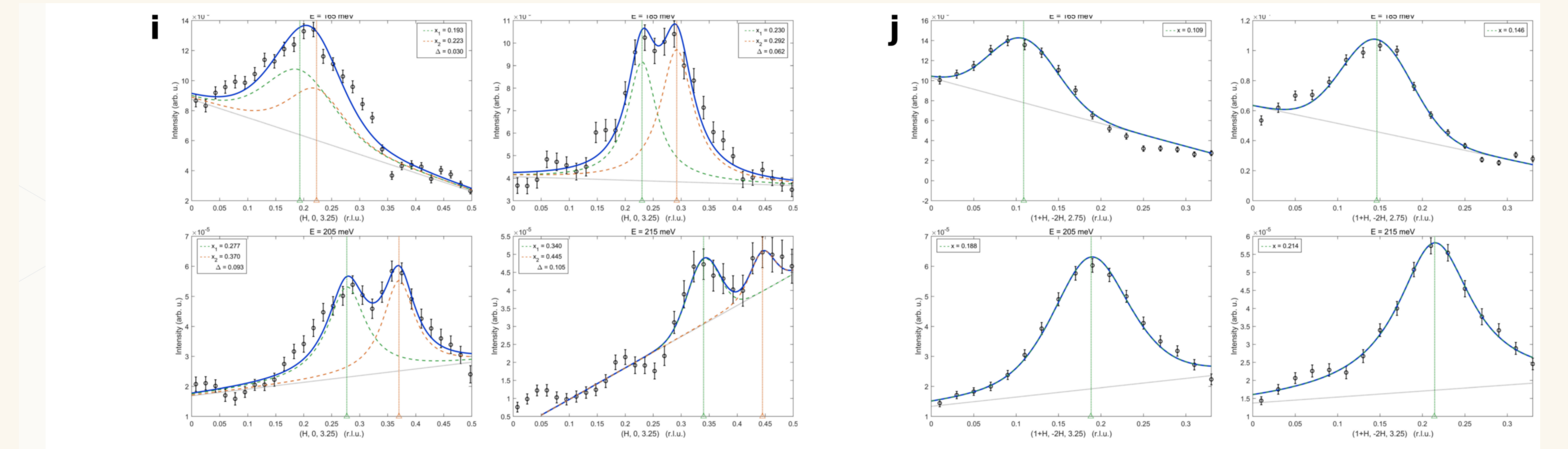
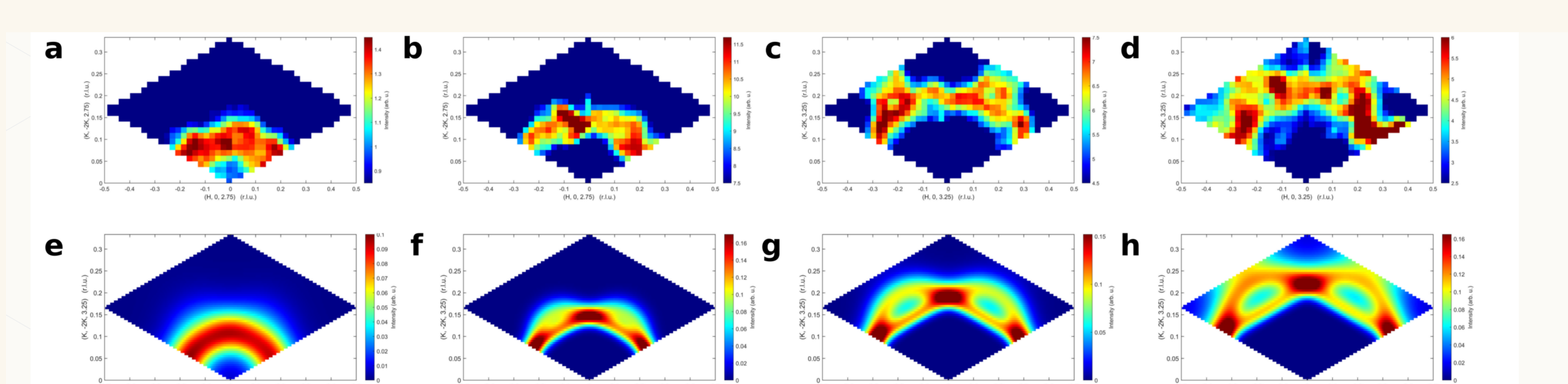
## RESULTS

### 1. Structure & crystal characterization



(a) Crystal structure:  $\text{Cr}^+$  (red) and  $\text{Cr}^-$  (blue) form opposite-spin sublattices coupled by spin-group symmetries [ $C_2 \parallel C_{6z}t$ ] and [ $C_2 \parallel M_z$ ] — the defining feature of an altermagnet. (b) Hexagonal first Brillouin zone, conventional high-symmetry points marked. (c) Backscattering Laue diffraction confirms the six-fold symmetry. (d)  $\rho(T)$  ( $i \parallel c$ ) shows metallic behavior. (e)  $\theta$ – $2\theta$  scan with only the (002) and (004) reflections confirms  $c$ -axis orientation.

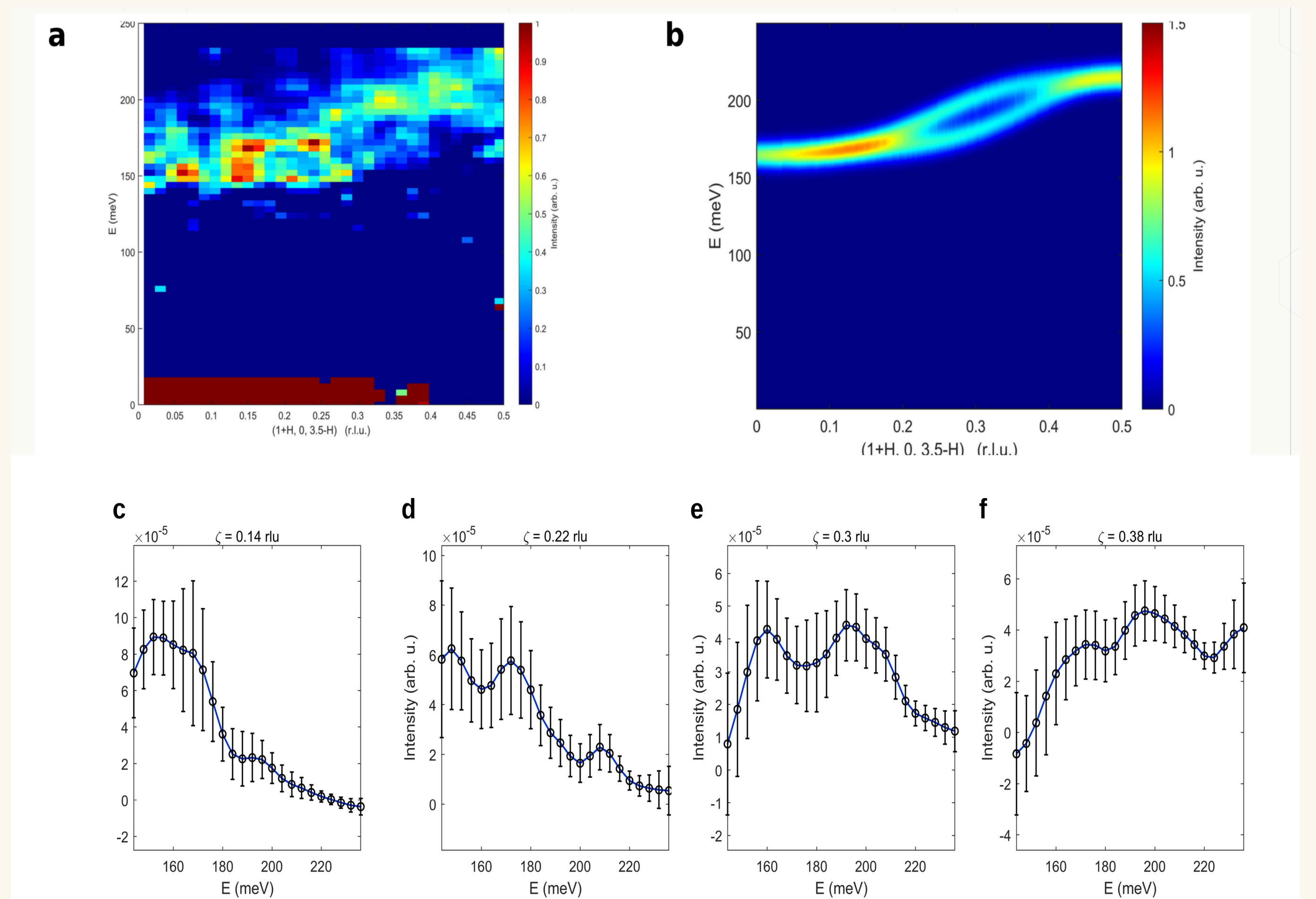
### 2. Altermagnetic magnon splitting in HK0



Constant-energy maps in the HK0 plane at  $E = 165, 185, 205, 215$  meV (a–d) reveal a single magnon arc at low energy that progressively splits into two branches with increasing energy — the direct experimental signature of altermagnetism-induced magnon splitting in CrSb. SpinW Heisenberg-model simulations (e–h) reproduce both the arc shape and the observed splitting using the fitted exchange parameters (in meV):  $J_1^{AB} = 28.00$ ,  $J_1^{AA} = -3.90$ ,  $J_2^{AB} = 5.95$ ,  $J_2^{AA} = 0$ ,  $J_6^{AA} = 1.50$ ,  $J_7^{AA} = 0$ , with intra-sublattice (AA) and inter-sublattice (AB) bonds labeled accordingly.

1D cuts along  $[1, 0, 0]$  (i), the direction of maximum predicted splitting, are fit with two pseudo-Voigt peaks; the splitting  $\Delta = x_2 - x_1$  grows monotonically from 0.030 r.l.u. at 165 meV to 0.105 r.l.u. at 215 meV. Cuts along the symmetry-degenerate (H,  $-2H$ , 0) direction (j) show a single peak at every energy, providing an independent symmetry-based confirmation of the altermagnetic model.

### 3. Magnon dispersion along A–M



(a) Measured  $Q$ – $E$  intensity map along A–M [the line  $(1+H, 0, 3.5-H)$ ,  $0 \leq H \leq 0.5$ ], zone-folded for statistics; the residual elastic line is at  $E < 20$  meV. (b) SpinW Heisenberg-model spectrum along the same path with the fitted exchanges — the dispersion rises from  $\sim 165$  meV near A to  $\sim 215$  meV near M. (c–f) Constant- $Q$  1D energy cuts at  $\zeta = 0.14, 0.22, 0.3, 0.38$  r.l.u. exhibit a two-peak structure indicative of altermagnetic splitting, most clearly resolved at  $\zeta \approx 0.22$  r.l.u. with peaks near  $\sim 150$  and  $\sim 170$  meV.

## CONCLUSION

- Direct INS observation of altermagnetism-induced magnon splitting in CrSb: the magnon arc in the HK0 plane splits monotonically with increasing energy (0.030  $\rightarrow$  0.105 r.l.u., 165  $\rightarrow$  215 meV).
- Quantitative microscopic model: a 6- $J$  Heisenberg Hamiltonian with intra- (AA) and inter-sublattice (AB) exchanges reproduces the dispersion across all measured high-symmetry directions.
- Symmetry-based confirmation: cuts along (H,  $-2H$ , 0) show a single peak at every energy, consistent with the  $g$ -wave altermagnetic symmetry of CrSb established by ARPES studies [2, 3].
- Our measurements complement the very recent first observation of magnon splitting in this material [1, 4] and extend it to in-plane HK0 reciprocal-space mapping with an independent set of fitted exchange parameters.
- Together with the high ordering temperature ( $T_N \approx 700$  K) and metallicity of CrSb, these results establish a robust platform for altermagnetic magnonics — long-lived, stray-field-free, chirality-resolved magnon transport above room temperature.
- Outlook: extension to additional reciprocal-space directions (in particular the predicted chiral splitting along  $\Gamma$ –L), investigation of doping- and strain-induced tuning, and exploration of proximity effects at altermagnet/superconductor interfaces enabled by CrSb's metallic ground state.

## REFERENCES

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- [4] Singh, Ashutosh K. *et al.*, *arXiv:2511.16086* (2025).