# First direct observation of incommensurate spin density wave and charge density wave on atomically flat Cr(001) surface with Spin-Polarized scanning tunneling microscopy

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Introduction

Origin of incommensurate spin density wave in Cr
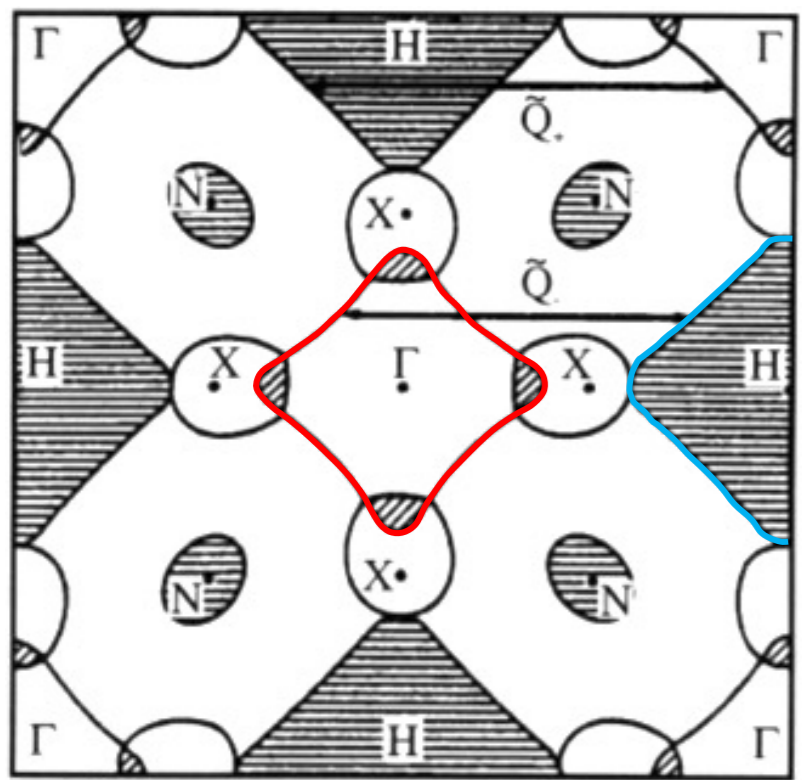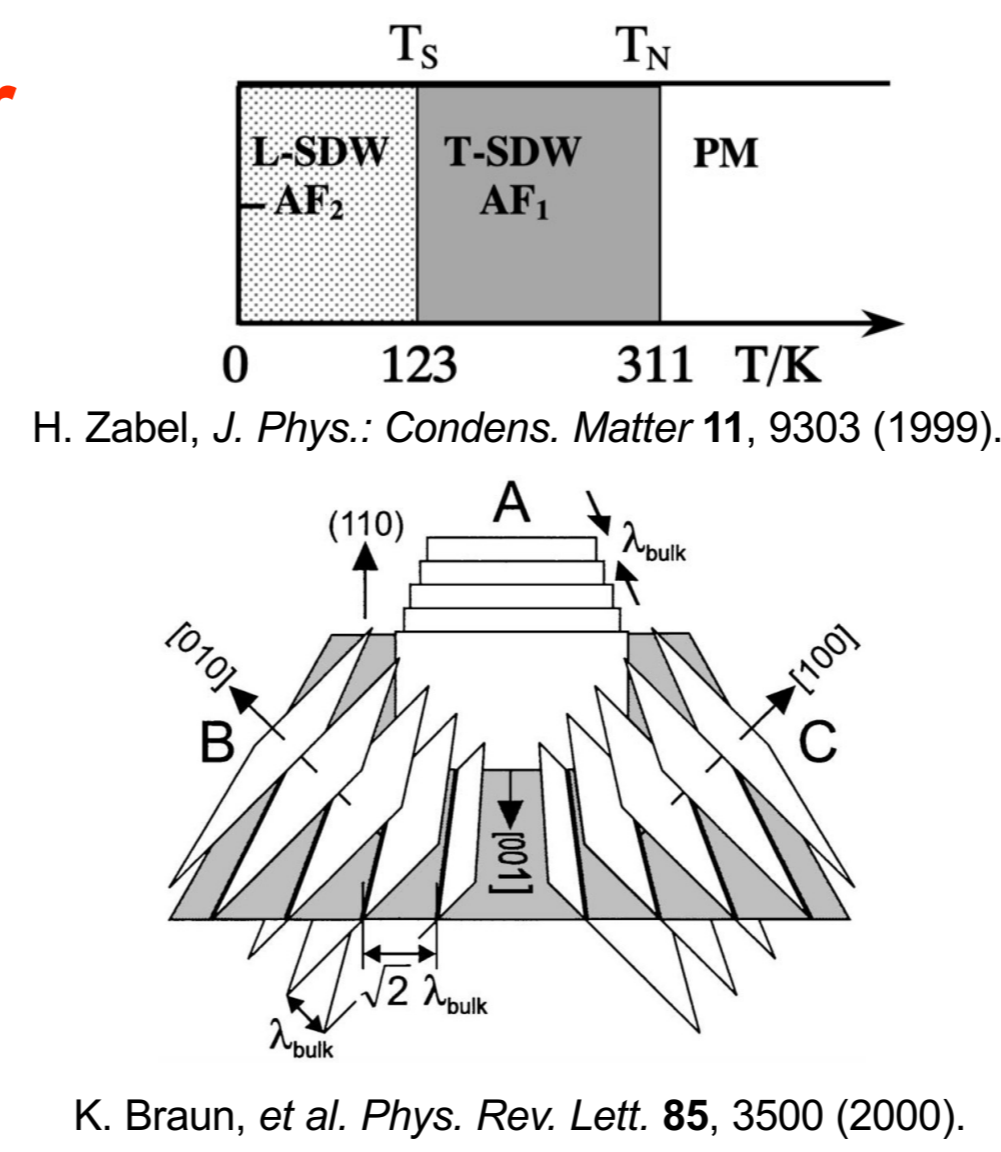
Imperfect Fermi surface nesting

$$Q_+ = \frac{2\pi}{a}(1+\delta)$$

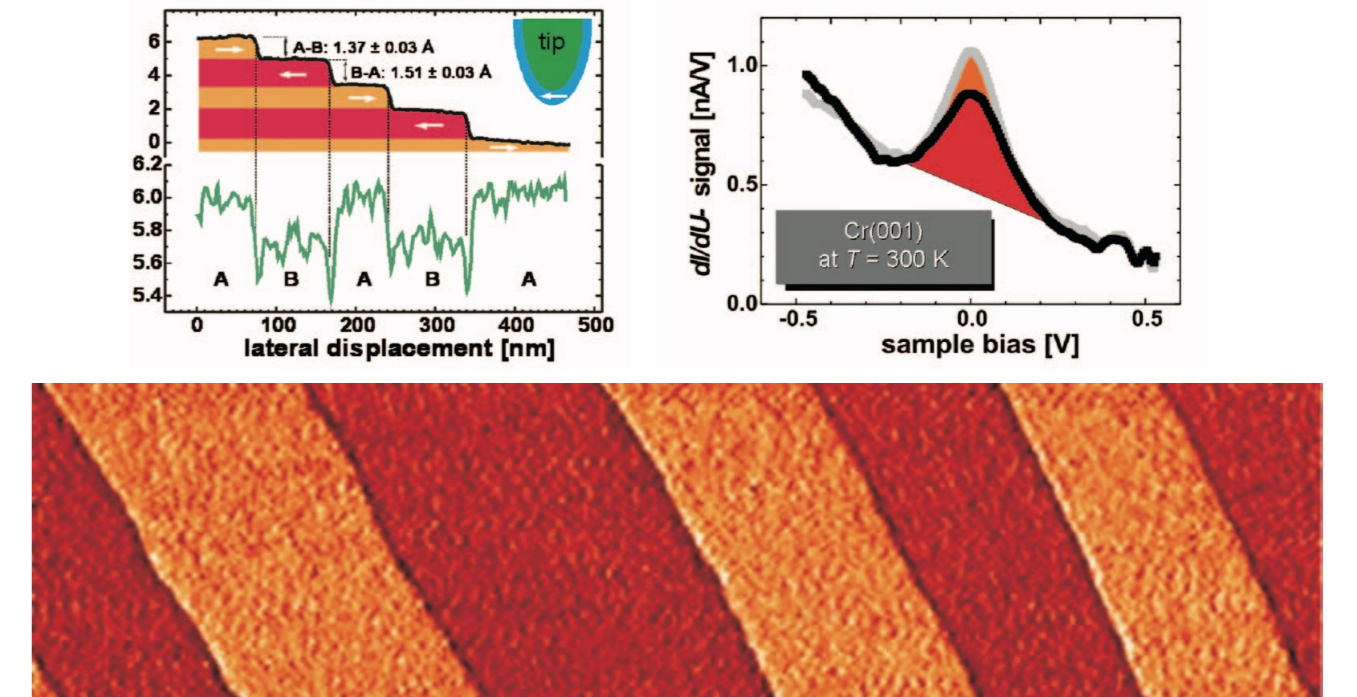$$Q_- = \frac{2\pi}{a}(1-\delta)$$

$$\delta \sim 0.05$$

Incommensurate factor
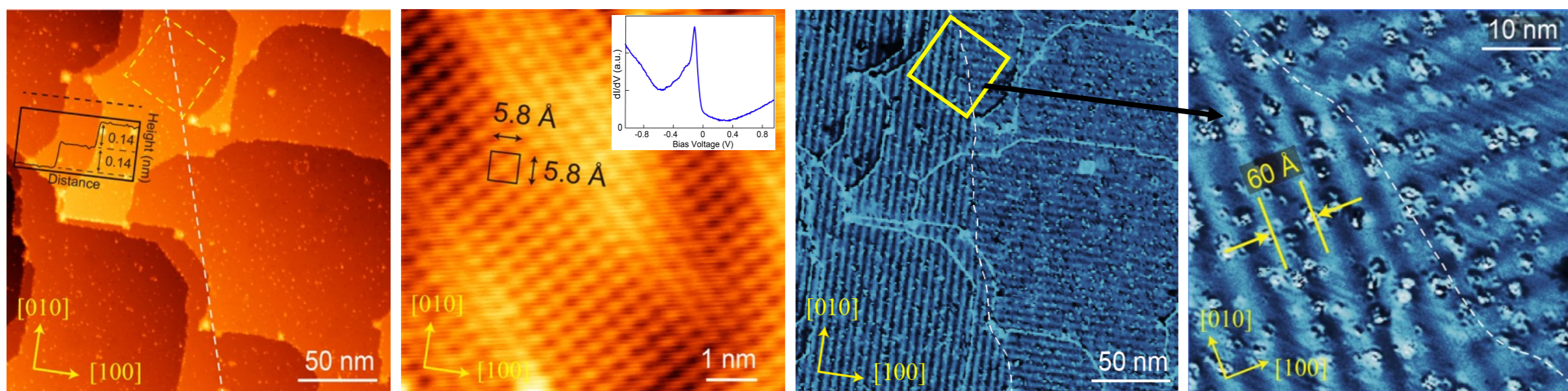
E. Fawcett, *Rev. Mod. Phys.* **60**, 209 (1988).

H. Zabel, *J. Phys.: Condens. Matter* **11**, 9303 (1999).

K. Braun, *et al. Phys. Rev. Lett.* **85**, 3500 (2000).

Absence of I-SDW in previous STM work

Antiferromagnetic order of Cr(001) surface

R. Wiesendanger, *Rev. Mod. Phys.* **81**, 1495 (2009).
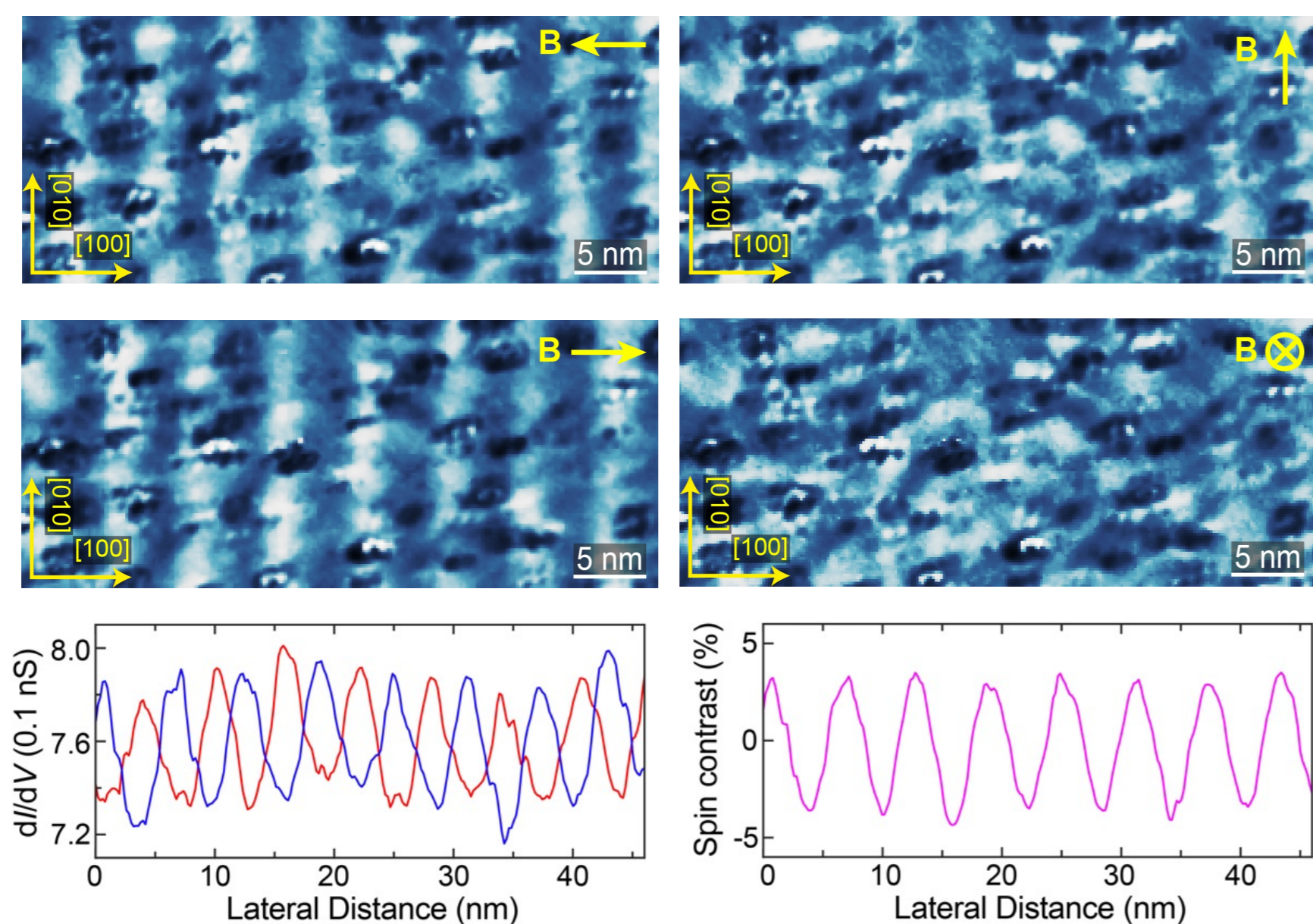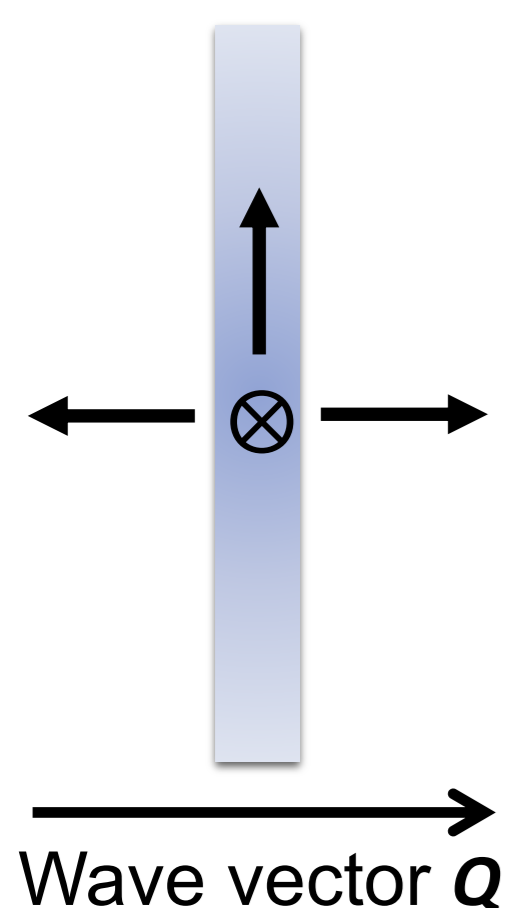
Verifying the nature of spin density wave

Domain boundary on well ordered Cr(001) surface

Imaging the spin density of states
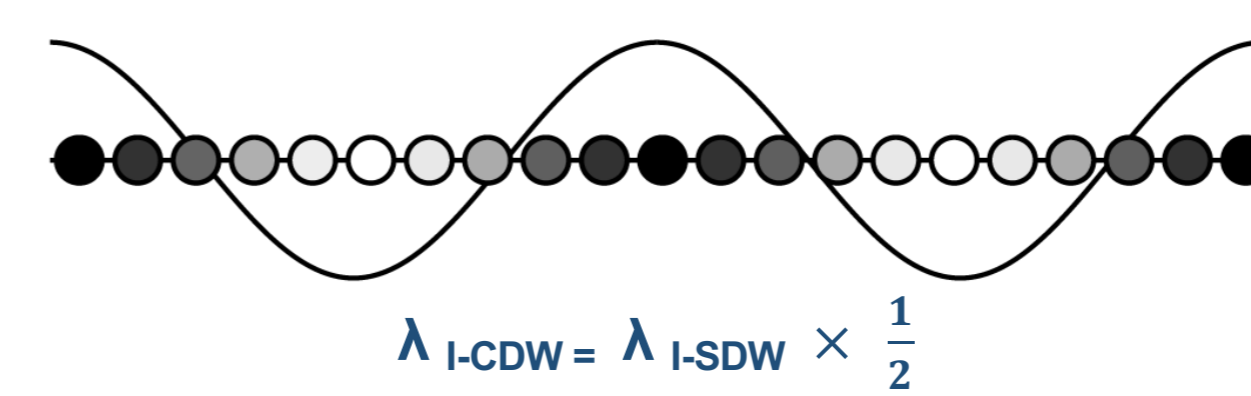
Fe-coated W tip
+
magnetic field

Wave vector **Q**

Longitudinal spin density wave with λ ~ 6 nm

Well matches the theory!

AFM coupling between neighboring terraces

Phase relation between SDW and CDW

Incommensurate spin density wave

$$\lambda_{\text{I-SDW}} \sim 22a \ (6.0 \ \text{nm})$$
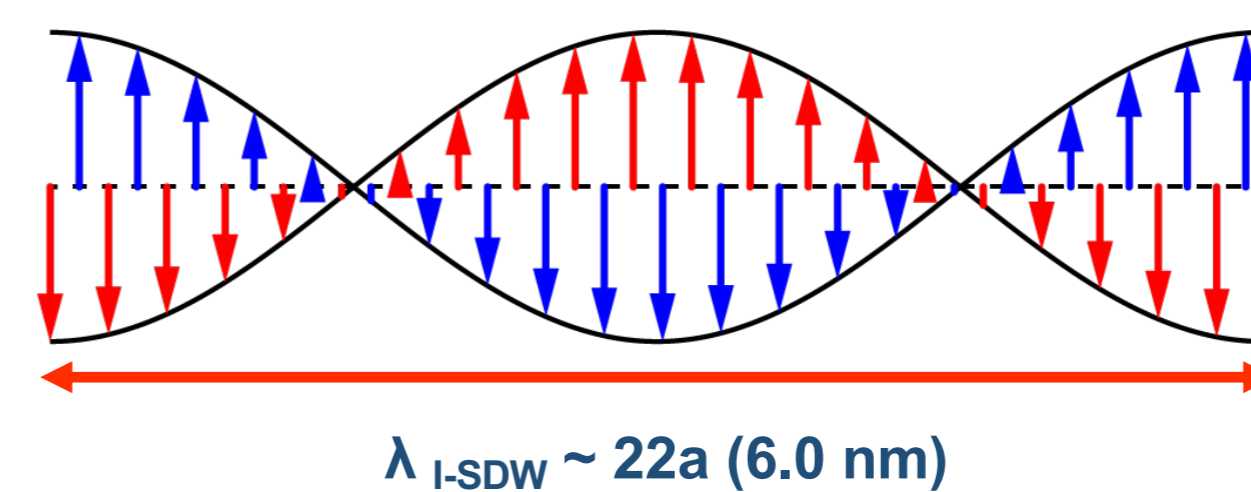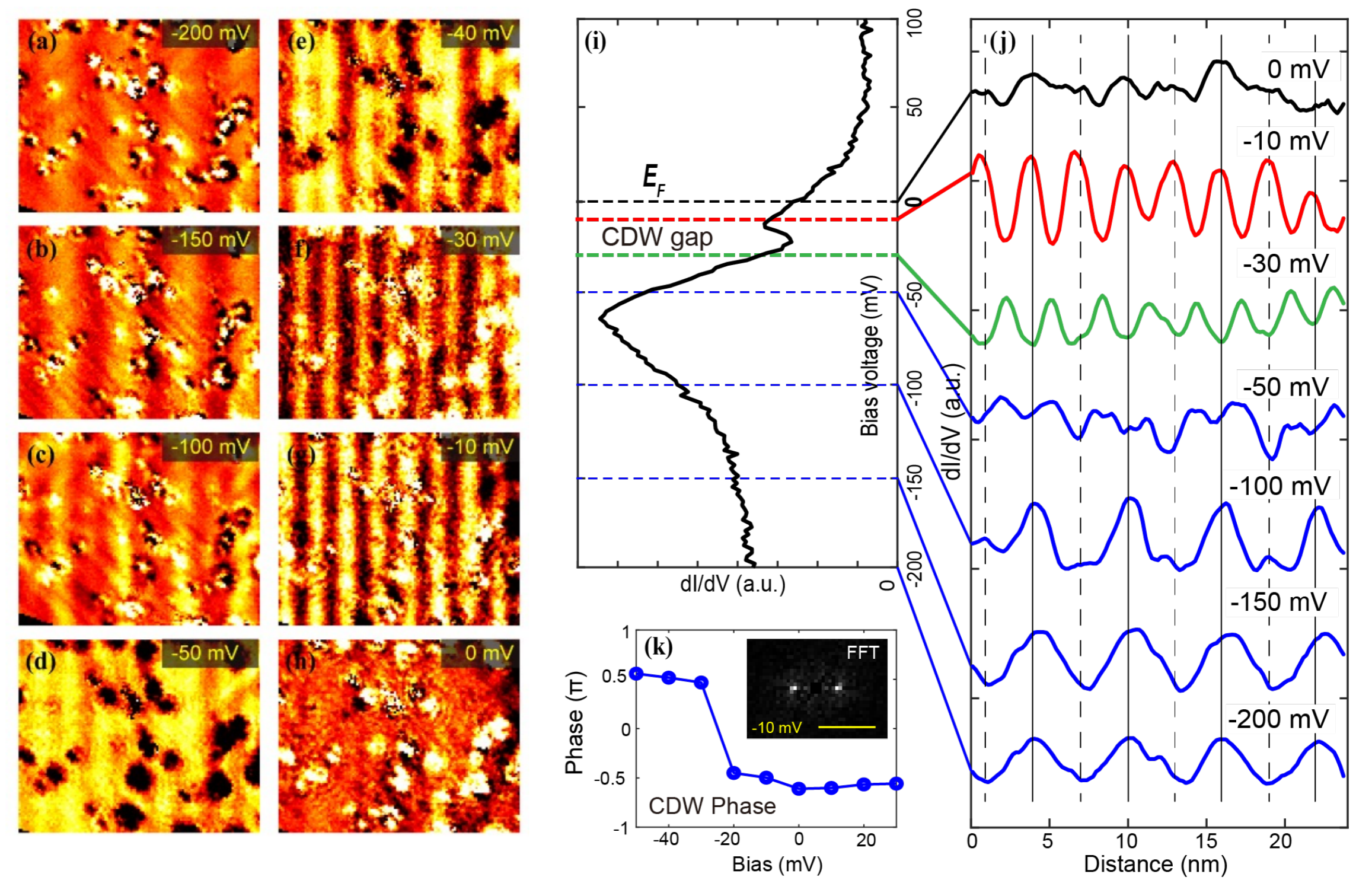
Incommensurate charge density wave

$$\lambda_{\text{I-CDW}} = \lambda_{\text{I-SDW}} \times \frac{1}{2}$$
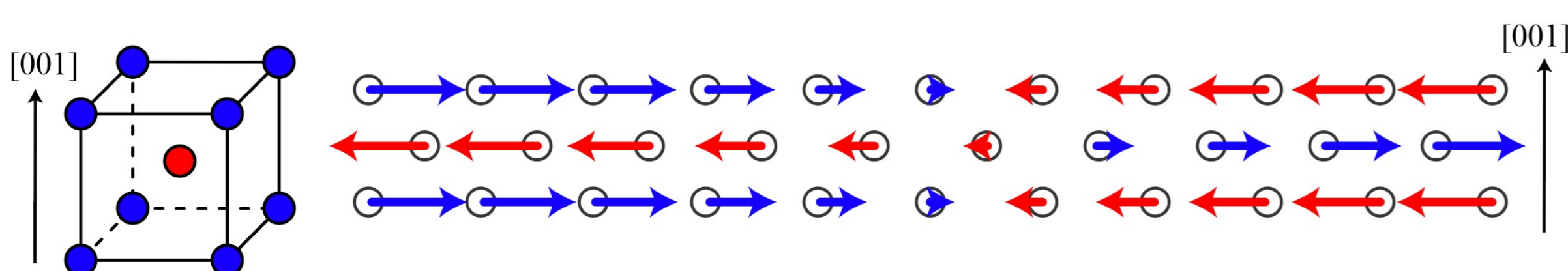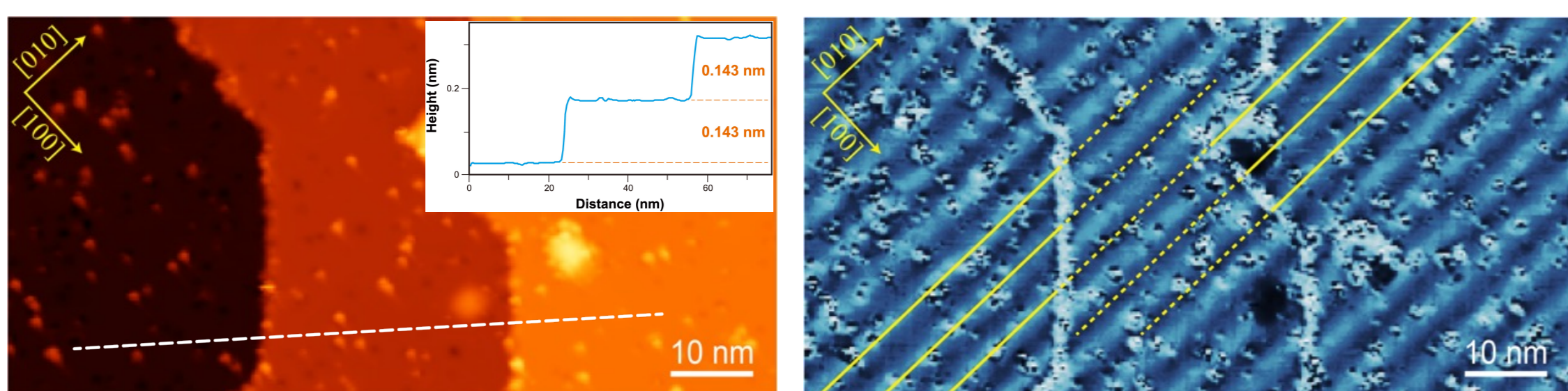
Summary

We present a direct observation of IC-SDW and CDW on a well cleaned Cr(001) surface, and particularly a CDW gap below E_F with clear phase inversion.

These new findings not only provide more insight on this classical SDW metal, but would also inspire more general study on the coexisting SDW/CDW orders. (Unpublished)

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