Question 1: Ni_3Al super alloy phase analysis

Single crystal super alloy turbine blades are based on the composition Ni_3Al. The Ni_3Al forms a γ FCC matrix which has a random distribution of the Ni and Al atoms on the lattice points (each lattice point 75% chance to be Ni, 25% chance to be Al), and coherent γ' precipitates in which the Ni and Al atoms order to form a simple cubic $L1_2$ structure.

a) For scattering from planes (*h k l*), the structure factor of a unit cell is given by the expression:

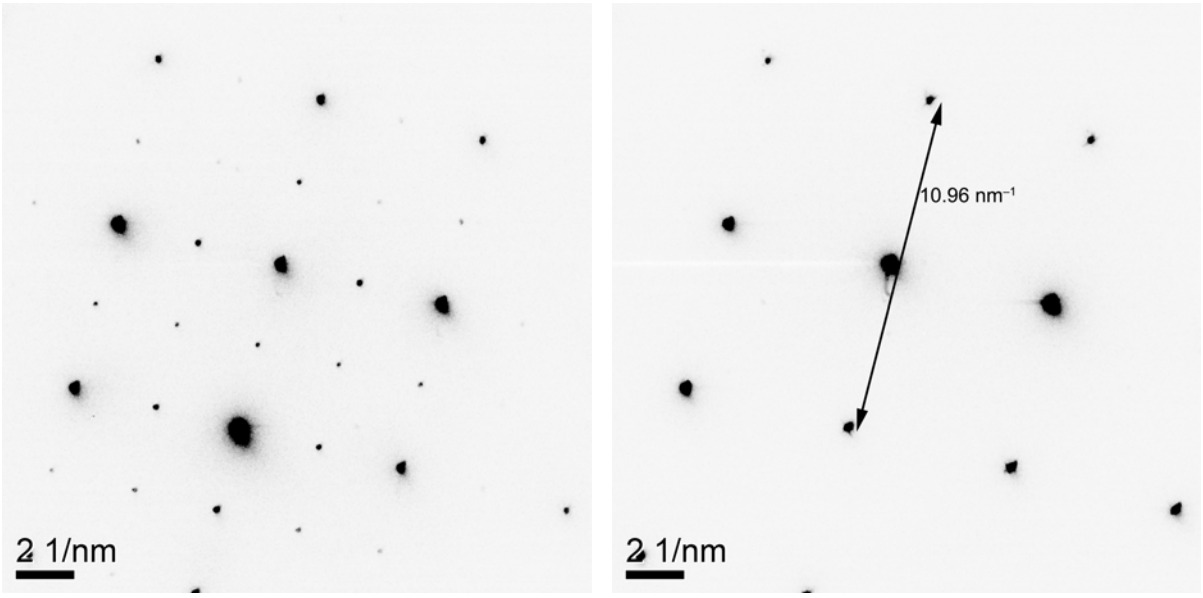
$$F_{hkl} = \sum_i f_i e^{2\pi i(hx_i + ky_i + lz_i)}$$

where f_i is the atomic scattering factor for each atom at position in the unit cell x_i, y_i, z_i.

For the γ' phase (atom positions below), calculate the structure factor rules for planes (*h k l*) in terms of atomic scattering factors f_{Ni} and f_{Al}.

#	Atom	Wyckoff	x	y	z
0	Al	a	0.000	0.000	0.000
1	Ni	c	0.000	0.500	0.500
2	Ni	c	0.500	0.500	0.000
3	Ni	c	0.500	0.000	0.500

b) The two nanobeam electron diffraction patterns below were taken from a superalloy sample prepared for TEM.



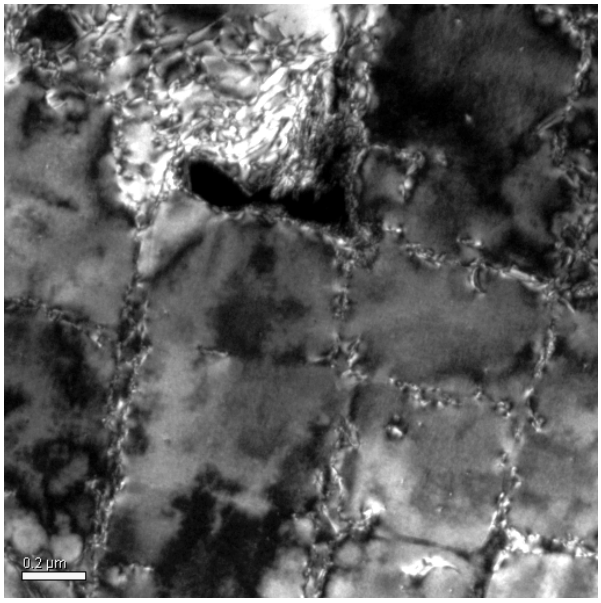
Which pattern comes from which phase?

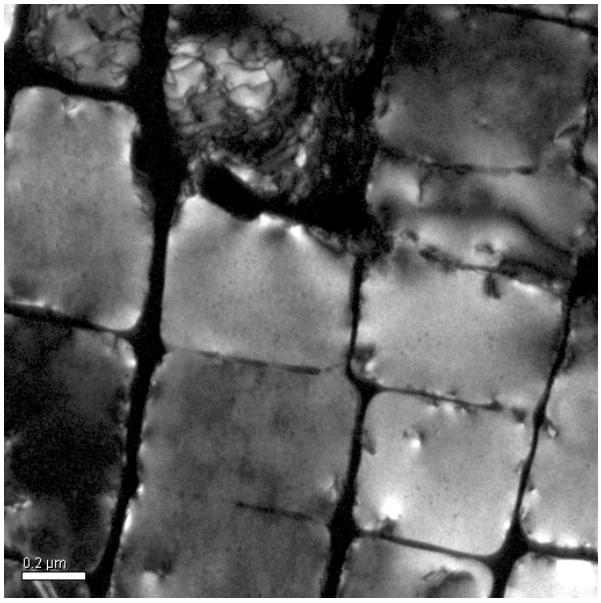
What is the zone axis for the patterns?

Index the reflections on the patterns.

From the reciprocal distance indicated calculate the lattice parameter *a*.

c) The DF images below were taken using different reflections from the Ni_3Al sample.





Which DF image shows the distribution of γ' precipitates?

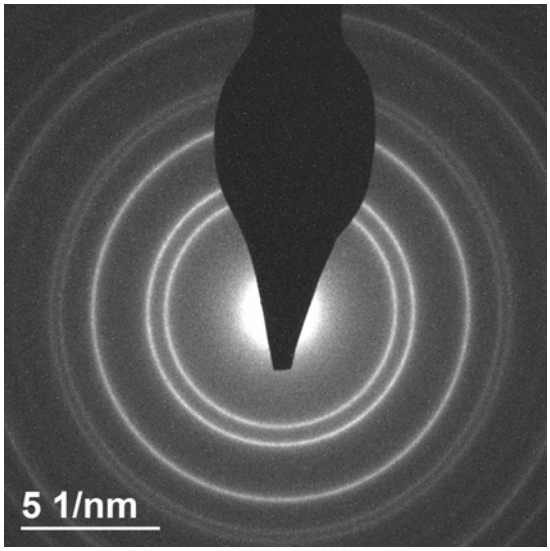
On the diffraction patterns in **b)** indicate reflections that could have been used to take each of the DF images.

From looking at the DF images, why was nanobeam electron diffraction used to take the diffraction patterns and not selected area diffraction?

What other features can you see in the DF images (particularly the one on the left)?

Question 2: SADP analysis nanocrystalline pattern

Below is a selected area diffraction pattern which was taken from a sample of a large number of nanocrystals.



This pattern comes from a material that is either FCC or BCC. How can we use the pattern to identify which?

The diameters of the first 5 rings are measured as:
8.27 nm^{-1}
9.62 nm^{-1}
13.64 nm^{-1}
15.95 nm^{-1}
16.6 nm^{-1}

From these identify if it is FCC or BCC and calculate the unit cell parameter *a*. Being cubic you can use the formula: