

$F4_132$

O^4

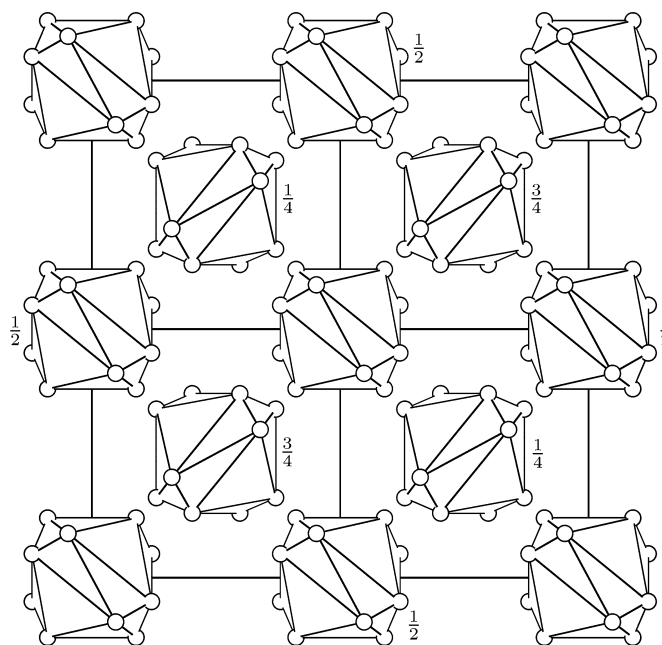
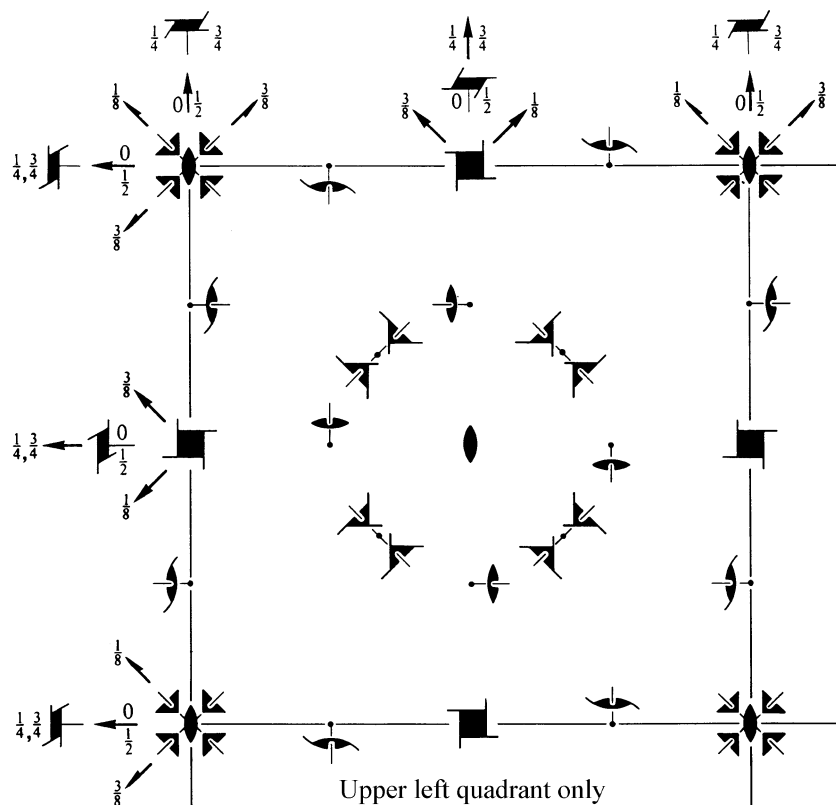
432

Cubic

No. 210

$F4_132$

Patterson symmetry $Fm\bar{3}m$



Origin at 23

Asymmetric unit $0 \leq x \leq \frac{1}{2}; -\frac{1}{8} \leq y \leq \frac{1}{8}; -\frac{1}{8} \leq z \leq \frac{1}{8}; y \leq \min(x, \frac{1}{2} - x); -y \leq z \leq \min(x, \frac{1}{2} - x)$
 Vertices $0, 0, 0$ $\frac{1}{8}, \frac{1}{8}, \frac{1}{8}$ $\frac{1}{8}, \frac{1}{8}, -\frac{1}{8}$ $\frac{1}{8}, -\frac{1}{8}, \frac{1}{8}$
 $\frac{1}{2}, 0, 0$ $\frac{3}{8}, \frac{1}{8}, \frac{1}{8}$ $\frac{3}{8}, \frac{1}{8}, -\frac{1}{8}$ $\frac{3}{8}, -\frac{1}{8}, \frac{1}{8}$

Symmetry operations

For $(0,0,0)+$ set

- | | | | |
|--|---|---|---|
| (1) 1 | (2) $2(0,0,\frac{1}{2})$ $0,\frac{1}{4},z$ | (3) $2(0,\frac{1}{2},0)$ $\frac{1}{4},y,0$ | (4) $2(\frac{1}{2},0,0)$ $x,0,\frac{1}{4}$ |
| (5) 3^+ x,x,x | (6) $3^+(\frac{1}{3},-\frac{1}{3},\frac{1}{3})$ $\bar{x}+\frac{1}{6},x+\frac{1}{6},\bar{x}$ | (7) $3^+(-\frac{1}{3},\frac{1}{3},\frac{1}{3})$ $x+\frac{1}{3},\bar{x}-\frac{1}{6},\bar{x}$ | (8) $3^+(\frac{1}{3},\frac{1}{3},-\frac{1}{3})$ $\bar{x}+\frac{1}{6},\bar{x}+\frac{1}{3},x$ |
| (9) 3^- x,x,x | (10) 3^- $x,\bar{x}+\frac{1}{2},\bar{x}$ | (11) 3^- $\bar{x}+\frac{1}{2},\bar{x},x$ | (12) 3^- $\bar{x}-\frac{1}{2},x+\frac{1}{2},\bar{x}$ |
| (13) $2(\frac{1}{2},\frac{1}{2},0)$ $x,x-\frac{1}{4},\frac{3}{8}z$ | (14) 2 $x,\bar{x}+\frac{1}{4},\frac{1}{8}z$ | (15) $4^-(0,0,\frac{3}{4})$ $\frac{1}{2},\frac{1}{4},z$ | (16) $4^+(0,0,\frac{1}{4})$ $0,\frac{3}{4},z$ |
| (17) $4^-(\frac{3}{4},0,0)$ $x,\frac{1}{2},\frac{1}{4}$ | (18) $2(0,\frac{1}{2},\frac{1}{2})$ $\frac{3}{8},y+\frac{1}{4},y$ | (19) 2 $\frac{1}{8},y+\frac{1}{4},\bar{y}$ | (20) $4^+(\frac{1}{4},0,0)$ $x,0,\frac{3}{4}$ |
| (21) $4^+(0,\frac{1}{4},0)$ $\frac{3}{4},y,0$ | (22) $2(\frac{1}{2},0,\frac{1}{2})$ $x-\frac{1}{4},\frac{3}{8},x$ | (23) $4^-(0,\frac{3}{4},0)$ $\frac{1}{4},y,\frac{1}{2}$ | (24) 2 $\bar{x}+\frac{1}{4},\frac{1}{8},x$ |

Symmetry operations (continued)

For $(0, \frac{1}{2}, \frac{1}{2})+$ set

- | | | | |
|--|--|--|--|
| (1) $t(0, \frac{1}{2}, \frac{1}{2})$ | (2) $2 \ 0, 0, z$ | (3) $2 \ \frac{1}{4}, y, \frac{1}{4}$ | (4) $2(\frac{1}{2}, 0, 0) \ x, \frac{1}{4}, 0$ |
| (5) $3^+(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x - \frac{1}{3}, x - \frac{1}{6}, x$ | (6) $3^+ \ \bar{x} + \frac{1}{2}, x, \bar{x}$ | (7) $3^+ \ x, \bar{x}, \bar{x}$ | (8) $3^+ \ \bar{x} + \frac{1}{2}, \bar{x} + \frac{1}{2}, x$ |
| (9) $3^-(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x - \frac{1}{6}, x + \frac{1}{6}, x$ | (10) $3^- \ x + \frac{1}{2}, \bar{x}, \bar{x}$ | (11) $3^-(\frac{1}{3}, \frac{1}{3}, -\frac{1}{3}) \ \bar{x} + \frac{1}{3}, \bar{x} + \frac{1}{6}, x$ | (12) $3^- \ \bar{x}, x, \bar{x}$ |
| (13) $2(\frac{3}{4}, \frac{3}{4}, 0) \ x, x, \frac{1}{8}$ | (14) $2(-\frac{1}{4}, \frac{3}{4}, 0) \ x, \bar{x} + \frac{1}{2}, \frac{3}{8}$ | (15) $4^-(0, 0, \frac{1}{4}) \ \frac{1}{4}, 0, z$ | (16) $4^+(0, 0, \frac{3}{4}) \ \frac{1}{4}, \frac{1}{2}, z$ |
| (17) $4^-(\frac{3}{4}, 0, 0) \ x, \frac{1}{2}, -\frac{1}{4}$ | (18) $2(0, \frac{1}{2}, \frac{1}{2}) \ \frac{3}{8}, y - \frac{1}{4}, y$ | (19) $2 \ \frac{1}{8}, y + \frac{3}{4}, \bar{y}$ | (20) $4^+(\frac{1}{4}, 0, 0) \ x, 0, \frac{1}{4}$ |
| (21) $4^+(0, \frac{3}{4}, 0) \ \frac{1}{2}, y, -\frac{1}{4}$ | (22) $2(\frac{1}{4}, 0, \frac{1}{4}) \ x, \frac{1}{8}, x$ | (23) $4^-(0, \frac{1}{4}, 0) \ 0, y, \frac{3}{4}$ | (24) $2(-\frac{1}{4}, 0, \frac{1}{4}) \ \bar{x} + \frac{1}{2}, \frac{3}{8}, x$ |

For $(\frac{1}{2}, 0, \frac{1}{2})+$ set

- | | | | |
|--|---|--|--|
| (1) $t(\frac{1}{2}, 0, \frac{1}{2})$ | (2) $2 \ \frac{1}{4}, \frac{1}{4}, z$ | (3) $2(0, \frac{1}{2}, 0) \ 0, y, \frac{1}{4}$ | (4) $2 \ x, 0, 0$ |
| (5) $3^+(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x + \frac{1}{6}, x - \frac{1}{6}, x$ | (6) $3^+ \ \bar{x}, x, \bar{x}$ | (7) $3^+ \ x + \frac{1}{2}, \bar{x}, \bar{x}$ | (8) $3^+ \ \bar{x}, \bar{x} + \frac{1}{2}, x$ |
| (9) $3^-(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x - \frac{1}{6}, x - \frac{1}{3}, x$ | (10) $3^-(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x + \frac{1}{6}, \bar{x} + \frac{1}{6}, \bar{x}$ | (11) $3^- \ \bar{x}, \bar{x}, x$ | (12) $3^- \ \bar{x}, x + \frac{1}{2}, \bar{x}$ |
| (13) $2(\frac{1}{4}, \frac{1}{4}, 0) \ x, x, \frac{1}{8}$ | (14) $2(\frac{1}{4}, -\frac{1}{4}, 0) \ x, \bar{x} + \frac{1}{2}, \frac{3}{8}$ | (15) $4^-(0, 0, \frac{1}{4}) \ \frac{3}{4}, 0, z$ | (16) $4^+(0, 0, \frac{3}{4}) \ -\frac{1}{4}, \frac{1}{2}, z$ |
| (17) $4^-(\frac{1}{4}, 0, 0) \ x, \frac{1}{4}, 0$ | (18) $2(0, \frac{3}{4}, \frac{3}{4}) \ \frac{1}{8}, y, y$ | (19) $2(0, -\frac{1}{4}, \frac{1}{4}) \ \frac{3}{8}, y + \frac{1}{2}, \bar{y}$ | (20) $4^+(\frac{3}{4}, 0, 0) \ x, \frac{1}{4}, \frac{1}{2}$ |
| (21) $4^+(0, \frac{1}{4}, 0) \ \frac{1}{4}, y, 0$ | (22) $2(\frac{1}{2}, 0, \frac{1}{2}) \ x + \frac{1}{4}, \frac{3}{8}, x$ | (23) $4^-(0, \frac{3}{4}, 0) \ -\frac{1}{4}, y, \frac{1}{2}$ | (24) $2 \ \bar{x} + \frac{3}{4}, \frac{1}{8}, x$ |

For $(\frac{1}{2}, \frac{1}{2}, 0)+$ set

- | | | | |
|--|---|--|--|
| (1) $t(\frac{1}{2}, \frac{1}{2}, 0)$ | (2) $2(0, 0, \frac{1}{2}) \ \frac{1}{4}, 0, z$ | (3) $2 \ 0, y, 0$ | (4) $2 \ x, \frac{1}{4}, \frac{1}{4}$ |
| (5) $3^+(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x + \frac{1}{6}, x + \frac{1}{3}, x$ | (6) $3^+ \ \bar{x}, x + \frac{1}{2}, \bar{x}$ | (7) $3^+ \ x + \frac{1}{2}, \bar{x} - \frac{1}{2}, \bar{x}$ | (8) $3^+ \ \bar{x}, \bar{x}, x$ |
| (9) $3^-(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}) \ x + \frac{1}{3}, x + \frac{1}{6}, x$ | (10) $3^- \ x, \bar{x}, \bar{x}$ | (11) $3^- \ \bar{x} + \frac{1}{2}, \bar{x} + \frac{1}{2}, x$ | (12) $3^-(\frac{1}{3}, -\frac{1}{3}, \frac{1}{3}) \ \bar{x} - \frac{1}{6}, x + \frac{1}{3}, \bar{x}$ |
| (13) $2(\frac{1}{2}, \frac{1}{2}, 0) \ x, x + \frac{1}{4}, \frac{3}{8}$ | (14) $2 \ x, \bar{x} + \frac{3}{4}, \frac{1}{8}$ | (15) $4^-(0, 0, \frac{3}{4}) \ \frac{1}{2}, -\frac{1}{4}, z$ | (16) $4^+(0, 0, \frac{1}{4}) \ 0, \frac{1}{4}, z$ |
| (17) $4^-(\frac{1}{4}, 0, 0) \ x, \frac{3}{4}, 0$ | (18) $2(0, \frac{1}{4}, \frac{1}{4}) \ \frac{1}{8}, y, y$ | (19) $2(0, \frac{1}{4}, -\frac{1}{4}) \ \frac{3}{8}, y + \frac{1}{2}, \bar{y}$ | (20) $4^+(\frac{3}{4}, 0, 0) \ x, -\frac{1}{4}, \frac{1}{2}$ |
| (21) $4^+(0, \frac{3}{4}, 0) \ \frac{1}{2}, y, \frac{1}{4}$ | (22) $2(\frac{3}{4}, 0, \frac{3}{4}) \ x, \frac{1}{8}, x$ | (23) $4^-(0, \frac{1}{4}, 0) \ 0, y, \frac{1}{4}$ | (24) $2(\frac{1}{4}, 0, -\frac{1}{4}) \ \bar{x} + \frac{1}{2}, \frac{3}{8}, x$ |

Generators selected (1); $t(1, 0, 0)$; $t(0, 1, 0)$; $t(0, 0, 1)$; $t(0, \frac{1}{2}, \frac{1}{2})$; $t(\frac{1}{2}, 0, \frac{1}{2})$; (2); (3); (5); (13)

Positions

Multiplicity, Wyckoff letter, Site symmetry	Coordinates				Reflection conditions
	$(0, 0, 0)+$	$(0, \frac{1}{2}, \frac{1}{2})+$	$(\frac{1}{2}, 0, \frac{1}{2})+$	$(\frac{1}{2}, \frac{1}{2}, 0)+$	h, k, l permutable General:
96 <i>h</i> 1	(1) x, y, z (5) z, x, y (9) y, z, x (13) $y + \frac{3}{4}, x + \frac{1}{4}, \bar{z} + \frac{3}{4}$ (17) $x + \frac{3}{4}, z + \frac{1}{4}, \bar{y} + \frac{3}{4}$ (21) $z + \frac{3}{4}, y + \frac{1}{4}, \bar{x} + \frac{3}{4}$	(2) $\bar{x}, \bar{y} + \frac{1}{2}, z + \frac{1}{2}$ (6) $z + \frac{1}{2}, \bar{x}, \bar{y} + \frac{1}{2}$ (10) $\bar{y} + \frac{1}{2}, z + \frac{1}{2}, \bar{x}$ (14) $\bar{y} + \frac{1}{4}, \bar{x} + \frac{1}{4}, \bar{z} + \frac{1}{4}$ (18) $\bar{x} + \frac{3}{4}, z + \frac{3}{4}, y + \frac{1}{4}$ (22) $z + \frac{1}{4}, \bar{y} + \frac{3}{4}, x + \frac{3}{4}$	(3) $\bar{x} + \frac{1}{2}, y + \frac{1}{2}, \bar{z}$ (7) $\bar{z}, \bar{x} + \frac{1}{2}, y + \frac{1}{2}$ (11) $y + \frac{1}{2}, \bar{z}, \bar{x} + \frac{1}{2}$ (15) $y + \frac{1}{4}, \bar{x} + \frac{3}{4}, z + \frac{3}{4}$ (19) $\bar{x} + \frac{1}{4}, \bar{z} + \frac{1}{4}, \bar{y} + \frac{1}{4}$ (23) $\bar{z} + \frac{3}{4}, y + \frac{3}{4}, x + \frac{1}{4}$	(4) $x + \frac{1}{2}, \bar{y}, \bar{z} + \frac{1}{2}$ (8) $\bar{z} + \frac{1}{2}, x + \frac{1}{2}, \bar{y}$ (12) $\bar{y}, \bar{z} + \frac{1}{2}, x + \frac{1}{2}$ (16) $\bar{y} + \frac{3}{4}, x + \frac{3}{4}, z + \frac{1}{4}$ (20) $x + \frac{1}{4}, \bar{z} + \frac{3}{4}, y + \frac{3}{4}$ (24) $\bar{z} + \frac{1}{4}, \bar{y} + \frac{1}{4}, \bar{x} + \frac{1}{4}$	$hkl: h + k = 2n$ and $h + l, k + l = 2n$ $Ok: k, l = 2n$ $hhl: h + l = 2n$ $h00: h = 4n$
48 <i>g</i> ..2	$\frac{1}{8}, y, \bar{y} + \frac{1}{4}$ $\bar{y} + \frac{1}{4}, \frac{1}{8}, y$ $y, \bar{y} + \frac{1}{4}, \frac{1}{8}$	$\frac{7}{8}, \bar{y} + \frac{1}{2}, \bar{y} + \frac{3}{4}$ $\bar{y} + \frac{3}{4}, \frac{7}{8}, \bar{y} + \frac{1}{2}$ $\bar{y} + \frac{1}{2}, \bar{y} + \frac{3}{4}, \frac{7}{8}$	$\frac{3}{8}, y + \frac{1}{2}, y + \frac{3}{4}$ $y + \frac{3}{4}, \frac{3}{8}, y + \frac{1}{2}$ $y + \frac{1}{2}, y + \frac{3}{4}, \frac{3}{8}$	$\frac{5}{8}, \bar{y}, y + \frac{1}{4}$ $y + \frac{1}{4}, \frac{5}{8}, \bar{y}$ $\bar{y}, y + \frac{1}{4}, \frac{5}{8}$	no extra conditions
48 <i>f</i> 2..	$x, 0, 0$ $\frac{3}{4}, x + \frac{1}{4}, \frac{3}{4}$	$\bar{x}, \frac{1}{2}, \frac{1}{2}$ $\frac{1}{4}, \bar{x} + \frac{1}{4}, \frac{1}{4}$	$0, x, 0$ $x + \frac{3}{4}, \frac{1}{4}, \frac{3}{4}$	$\frac{1}{2}, \bar{x}, \frac{1}{2}$ $\bar{x} + \frac{3}{4}, \frac{3}{4}, \frac{1}{4}$ $\frac{3}{4}, \frac{1}{4}, \bar{x} + \frac{3}{4}$	$\frac{1}{2}, \frac{1}{2}, \bar{x}$ $\frac{1}{4}, \frac{3}{4}, x + \frac{3}{4}$ $hkl: h = 2n + 1$ or $h + k + l = 4n$
32 <i>e</i> .3.	x, x, x $x + \frac{3}{4}, x + \frac{1}{4}, \bar{x} + \frac{3}{4}$	$\bar{x}, \bar{x} + \frac{1}{2}, x + \frac{1}{2}$ $\bar{x} + \frac{1}{4}, \bar{x} + \frac{1}{4}, \bar{x} + \frac{1}{4}$	$\bar{x} + \frac{1}{2}, x + \frac{1}{2}, \bar{x}$ $x + \frac{1}{4}, \bar{x} + \frac{3}{4}, x + \frac{3}{4}$	$x + \frac{1}{2}, \bar{x}, \bar{x} + \frac{1}{2}$ $\bar{x} + \frac{3}{4}, x + \frac{3}{4}, x + \frac{1}{4}$	$Ok: k + l = 4n$
16 <i>d</i> .32	$\frac{5}{8}, \frac{5}{8}, \frac{5}{8}$	$\frac{3}{8}, \frac{7}{8}, \frac{1}{8}$	$\frac{7}{8}, \frac{1}{8}, \frac{3}{8}$	$\frac{1}{8}, \frac{3}{8}, \frac{7}{8}$	} $hkl: h = 2n + 1$ or $h, k, l = 4n + 2$ or $h, k, l = 4n$
16 <i>c</i> .32	$\frac{1}{8}, \frac{1}{8}, \frac{1}{8}$	$\frac{7}{8}, \frac{3}{8}, \frac{5}{8}$	$\frac{3}{8}, \frac{5}{8}, \frac{7}{8}$	$\frac{5}{8}, \frac{7}{8}, \frac{3}{8}$	
8 <i>b</i> 23.	$\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$	$\frac{1}{4}, \frac{3}{4}, \frac{1}{4}$			} $hkl: h = 2n + 1$ or $h + k + l = 4n$
8 <i>a</i> 23.	$0, 0, 0$	$\frac{3}{4}, \frac{1}{4}, \frac{3}{4}$			

Symmetry of special projections

Along $[001] \ p4mm$ $\mathbf{a}' = \frac{1}{2}\mathbf{a} \quad \mathbf{b}' = \frac{1}{2}\mathbf{b}$ Origin at $\frac{1}{4}, 0, z$	Along $[111] \ p3m1$ $\mathbf{a}' = \frac{1}{6}(2\mathbf{a} - \mathbf{b} - \mathbf{c}) \quad \mathbf{b}' = \frac{1}{6}(-\mathbf{a} + 2\mathbf{b} - \mathbf{c})$ Origin at x, x, x	Along $[110] \ c2mm$ $\mathbf{a}' = \frac{1}{2}(-\mathbf{a} + \mathbf{b}) \quad \mathbf{b}' = \mathbf{c}$ Origin at $x, x, \frac{1}{8}$
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