α-$Bi_4V_2O_{11}$ Structure: A3B9C2_mC112_5_6c_2a2b16c_4c-001

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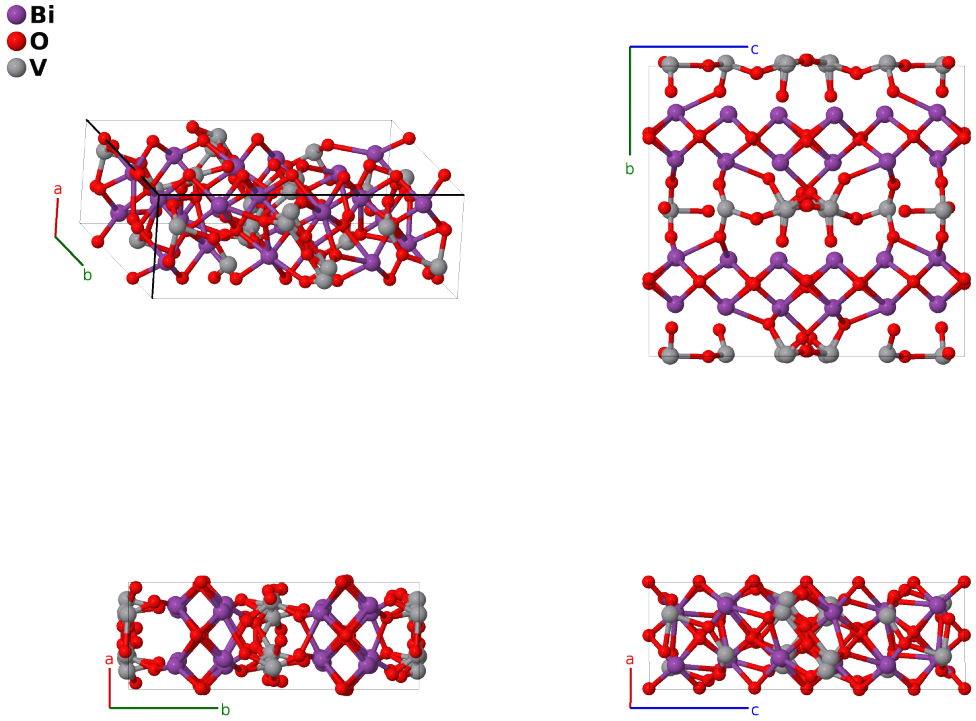
https://aflow.org/p/JBQX

https://aflow.org/p/A3B9C2_mC112_5_6c_2a2b16c_4c-001



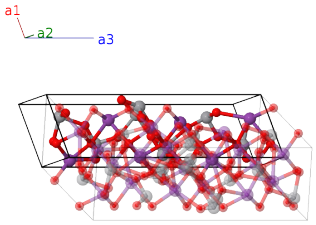
Prototype	$Bi_4O_{11}V_2$
AFLOW prototype label	A3B9C2_mC112_5_6c_2a2b16c_4c-001
ICSD	98589
Pearson symbol	mC112
Space group number	5
Space group symbol	$C2$
AFLOW prototype command	`aflow --proto=A3B9C2_mC112_5_6c_2a2b16c_4c-001 --params=`$a, b/a, c/a, \beta, y_1, y_2, y_3, y_4, x_5, y_5, z_5, x_6, y_6, z_6, x_7, y_7, z_7, x_8, y_8, z_8, x_9, y_9, z_9, x_{10}, y_{10}, z_{10}, x_{11}, y_{11}, z_{11}, x_{12}, y_{12}, z_{12}, x_{13}, y_{13}, z_{13}, x_{14}, y_{14}, z_{14}, x_{15}, y_{15}, z_{15}, x_{16}, y_{16}, z_{16}, x_{17}, y_{17}, z_{17}, x_{18}, y_{18}, z_{18}, x_{19}, y_{19}, z_{19}, x_{20}, y_{20}, z_{20}, x_{21}, y_{21}, z_{21}, x_{22}, y_{22}, z_{22}, x_{23}, y_{23}, z_{23}, x_{24}, y_{24}, z_{24}, x_{25}, y_{25}, z_{25}, x_{26}, y_{26}, z_{26}, x_{27}, y_{27}, z_{27}, x_{28}, y_{28}, z_{28}, x_{29}, y_{29}, z_{29}, x_{30}, y_{30}, z_{30}$

- There are three known varieties of $Bi_4V_2O_{11}$ (Villars, 2018):

  - α, the ground state structure, stable up to 450°C (this structure),
  - β, stable between 450°C and 555°C, and
  - γ, stable from 555°C up to the melting point at 880°C.
- The sites we have labeled O-XXIV, O-XXV, O-XXVI, V-III, and V-IV are each only occupied 50% of the time in any one primitive cell.
- (Mairesse, 2003) describe the structure of α-$Bi_4V_2O_{11}$ in the $A2$ setting of space group #5 with unique axis c. We describe it in our standard setting, $C2$ with unique axis b.

Base-centered Monoclinic primitive vectors

$$\begin{aligned}
\mathbf{a_1} &= \tfrac{1}{2}a\,\hat{\mathbf{x}} - \tfrac{1}{2}b\,\hat{\mathbf{y}} \\
\mathbf{a_2} &= \tfrac{1}{2}a\,\hat{\mathbf{x}} + \tfrac{1}{2}b\,\hat{\mathbf{y}} \\
\mathbf{a_3} &= c\cos\beta\,\hat{\mathbf{x}} + c\sin\beta\,\hat{\mathbf{z}}
\end{aligned}$$



Basis vectors

		Lattice coordinates		Cartesian coordinates	Wyckoff position	Atom type
$\mathbf{B_1}$	=	$-y_1\,\mathbf{a}_1 + y_1\,\mathbf{a}_2$	=	$by_1\,\hat{\mathbf{y}}$	(2a)	O I
$\mathbf{B_2}$	=	$-y_2\,\mathbf{a}_1 + y_2\,\mathbf{a}_2$	=	$by_2\,\hat{\mathbf{y}}$	(2a)	O II
$\mathbf{B_3}$	=	$-y_3\,\mathbf{a}_1 + y_3\,\mathbf{a}_2 + \frac{1}{2}\,\mathbf{a}_3$	=	$\frac{1}{2}c\cos\beta\,\hat{\mathbf{x}} + by_3\,\hat{\mathbf{y}} + \frac{1}{2}c\sin\beta\,\hat{\mathbf{z}}$	(2b)	O III
$\mathbf{B_4}$	=	$-y_4\,\mathbf{a}_1 + y_4\,\mathbf{a}_2 + \frac{1}{2}\,\mathbf{a}_3$	=	$\frac{1}{2}c\cos\beta\,\hat{\mathbf{x}} + by_4\,\hat{\mathbf{y}} + \frac{1}{2}c\sin\beta\,\hat{\mathbf{z}}$	(2b)	O IV
$\mathbf{B_5}$	=	$(x_5 - y_5)\,\mathbf{a}_1 + (x_5 + y_5)\,\mathbf{a}_2 + z_5\,\mathbf{a}_3$	=	$(ax_5 + cz_5\cos\beta)\,\hat{\mathbf{x}} + by_5\,\hat{\mathbf{y}} + cz_5\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi I
$\mathbf{B_6}$	=	$-(x_5 + y_5)\,\mathbf{a}_1 - (x_5 - y_5)\,\mathbf{a}_2 - z_5\,\mathbf{a}_3$	=	$-(ax_5 + cz_5\cos\beta)\,\hat{\mathbf{x}} + by_5\,\hat{\mathbf{y}} - cz_5\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi I
$\mathbf{B_7}$	=	$(x_6 - y_6)\,\mathbf{a}_1 + (x_6 + y_6)\,\mathbf{a}_2 + z_6\,\mathbf{a}_3$	=	$(ax_6 + cz_6\cos\beta)\,\hat{\mathbf{x}} + by_6\,\hat{\mathbf{y}} + cz_6\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi II
$\mathbf{B_8}$	=	$-(x_6 + y_6)\,\mathbf{a}_1 - (x_6 - y_6)\,\mathbf{a}_2 - z_6\,\mathbf{a}_3$	=	$-(ax_6 + cz_6\cos\beta)\,\hat{\mathbf{x}} + by_6\,\hat{\mathbf{y}} - cz_6\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi II
$\mathbf{B_9}$	=	$(x_7 - y_7)\,\mathbf{a}_1 + (x_7 + y_7)\,\mathbf{a}_2 + z_7\,\mathbf{a}_3$	=	$(ax_7 + cz_7\cos\beta)\,\hat{\mathbf{x}} + by_7\,\hat{\mathbf{y}} + cz_7\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi III
$\mathbf{B_{10}}$	=	$-(x_7 + y_7)\,\mathbf{a}_1 - (x_7 - y_7)\,\mathbf{a}_2 - z_7\,\mathbf{a}_3$	=	$-(ax_7 + cz_7\cos\beta)\,\hat{\mathbf{x}} + by_7\,\hat{\mathbf{y}} - cz_7\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi III
$\mathbf{B_{11}}$	=	$(x_8 - y_8)\,\mathbf{a}_1 + (x_8 + y_8)\,\mathbf{a}_2 + z_8\,\mathbf{a}_3$	=	$(ax_8 + cz_8\cos\beta)\,\hat{\mathbf{x}} + by_8\,\hat{\mathbf{y}} + cz_8\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi IV
$\mathbf{B_{12}}$	=	$-(x_8 + y_8)\,\mathbf{a}_1 - (x_8 - y_8)\,\mathbf{a}_2 - z_8\,\mathbf{a}_3$	=	$-(ax_8 + cz_8\cos\beta)\,\hat{\mathbf{x}} + by_8\,\hat{\mathbf{y}} - cz_8\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi IV
$\mathbf{B_{13}}$	=	$(x_9 - y_9)\,\mathbf{a}_1 + (x_9 + y_9)\,\mathbf{a}_2 + z_9\,\mathbf{a}_3$	=	$(ax_9 + cz_9\cos\beta)\,\hat{\mathbf{x}} + by_9\,\hat{\mathbf{y}} + cz_9\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi V
$\mathbf{B_{14}}$	=	$-(x_9 + y_9)\,\mathbf{a}_1 - (x_9 - y_9)\,\mathbf{a}_2 - z_9\,\mathbf{a}_3$	=	$-(ax_9 + cz_9\cos\beta)\,\hat{\mathbf{x}} + by_9\,\hat{\mathbf{y}} - cz_9\sin\beta\,\hat{\mathbf{z}}$	(4c)	Bi V

$$\mathbf{B_{15}} = (x_{10}-y_{10})\,\mathbf{a}_1 + (x_{10}+y_{10})\,\mathbf{a}_2 + z_{10}\,\mathbf{a}_3 = (ax_{10}+cz_{10}\cos\beta)\,\hat{\mathbf{x}} + by_{10}\,\hat{\mathbf{y}} + cz_{10}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{Bi VI}$$

$$\mathbf{B_{16}} = -(x_{10}+y_{10})\,\mathbf{a}_1 - (x_{10}-y_{10})\,\mathbf{a}_2 - z_{10}\,\mathbf{a}_3 = -(ax_{10}+cz_{10}\cos\beta)\,\hat{\mathbf{x}} + by_{10}\,\hat{\mathbf{y}} - cz_{10}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{Bi VI}$$

$$\mathbf{B_{17}} = (x_{11}-y_{11})\,\mathbf{a}_1 + (x_{11}+y_{11})\,\mathbf{a}_2 + z_{11}\,\mathbf{a}_3 = (ax_{11}+cz_{11}\cos\beta)\,\hat{\mathbf{x}} + by_{11}\,\hat{\mathbf{y}} + cz_{11}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O V}$$

$$\mathbf{B_{18}} = -(x_{11}+y_{11})\,\mathbf{a}_1 - (x_{11}-y_{11})\,\mathbf{a}_2 - z_{11}\,\mathbf{a}_3 = -(ax_{11}+cz_{11}\cos\beta)\,\hat{\mathbf{x}} + by_{11}\,\hat{\mathbf{y}} - cz_{11}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O V}$$

$$\mathbf{B_{19}} = (x_{12}-y_{12})\,\mathbf{a}_1 + (x_{12}+y_{12})\,\mathbf{a}_2 + z_{12}\,\mathbf{a}_3 = (ax_{12}+cz_{12}\cos\beta)\,\hat{\mathbf{x}} + by_{12}\,\hat{\mathbf{y}} + cz_{12}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VI}$$

$$\mathbf{B_{20}} = -(x_{12}+y_{12})\,\mathbf{a}_1 - (x_{12}-y_{12})\,\mathbf{a}_2 - z_{12}\,\mathbf{a}_3 = -(ax_{12}+cz_{12}\cos\beta)\,\hat{\mathbf{x}} + by_{12}\,\hat{\mathbf{y}} - cz_{12}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VI}$$

$$\mathbf{B_{21}} = (x_{13}-y_{13})\,\mathbf{a}_1 + (x_{13}+y_{13})\,\mathbf{a}_2 + z_{13}\,\mathbf{a}_3 = (ax_{13}+cz_{13}\cos\beta)\,\hat{\mathbf{x}} + by_{13}\,\hat{\mathbf{y}} + cz_{13}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VII}$$

$$\mathbf{B_{22}} = -(x_{13}+y_{13})\,\mathbf{a}_1 - (x_{13}-y_{13})\,\mathbf{a}_2 - z_{13}\,\mathbf{a}_3 = -(ax_{13}+cz_{13}\cos\beta)\,\hat{\mathbf{x}} + by_{13}\,\hat{\mathbf{y}} - cz_{13}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VII}$$

$$\mathbf{B_{23}} = (x_{14}-y_{14})\,\mathbf{a}_1 + (x_{14}+y_{14})\,\mathbf{a}_2 + z_{14}\,\mathbf{a}_3 = (ax_{14}+cz_{14}\cos\beta)\,\hat{\mathbf{x}} + by_{14}\,\hat{\mathbf{y}} + cz_{14}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VIII}$$

$$\mathbf{B_{24}} = -(x_{14}+y_{14})\,\mathbf{a}_1 - (x_{14}-y_{14})\,\mathbf{a}_2 - z_{14}\,\mathbf{a}_3 = -(ax_{14}+cz_{14}\cos\beta)\,\hat{\mathbf{x}} + by_{14}\,\hat{\mathbf{y}} - cz_{14}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O VIII}$$

$$\mathbf{B_{25}} = (x_{15}-y_{15})\,\mathbf{a}_1 + (x_{15}+y_{15})\,\mathbf{a}_2 + z_{15}\,\mathbf{a}_3 = (ax_{15}+cz_{15}\cos\beta)\,\hat{\mathbf{x}} + by_{15}\,\hat{\mathbf{y}} + cz_{15}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O IX}$$

$$\mathbf{B_{26}} = -(x_{15}+y_{15})\,\mathbf{a}_1 - (x_{15}-y_{15})\,\mathbf{a}_2 - z_{15}\,\mathbf{a}_3 = -(ax_{15}+cz_{15}\cos\beta)\,\hat{\mathbf{x}} + by_{15}\,\hat{\mathbf{y}} - cz_{15}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O IX}$$

$$\mathbf{B_{27}} = (x_{16}-y_{16})\,\mathbf{a}_1 + (x_{16}+y_{16})\,\mathbf{a}_2 + z_{16}\,\mathbf{a}_3 = (ax_{16}+cz_{16}\cos\beta)\,\hat{\mathbf{x}} + by_{16}\,\hat{\mathbf{y}} + cz_{16}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O X}$$

$$\mathbf{B_{28}} = -(x_{16}+y_{16})\,\mathbf{a}_1 - (x_{16}-y_{16})\,\mathbf{a}_2 - z_{16}\,\mathbf{a}_3 = -(ax_{16}+cz_{16}\cos\beta)\,\hat{\mathbf{x}} + by_{16}\,\hat{\mathbf{y}} - cz_{16}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O X}$$

$$\mathbf{B_{29}} = (x_{17}-y_{17})\,\mathbf{a}_1 + (x_{17}+y_{17})\,\mathbf{a}_2 + z_{17}\,\mathbf{a}_3 = (ax_{17}+cz_{17}\cos\beta)\,\hat{\mathbf{x}} + by_{17}\,\hat{\mathbf{y}} + cz_{17}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XI}$$

$$\mathbf{B_{30}} = -(x_{17}+y_{17})\,\mathbf{a}_1 - (x_{17}-y_{17})\,\mathbf{a}_2 - z_{17}\,\mathbf{a}_3 = -(ax_{17}+cz_{17}\cos\beta)\,\hat{\mathbf{x}} + by_{17}\,\hat{\mathbf{y}} - cz_{17}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XI}$$

$$\mathbf{B_{31}} = (x_{18}-y_{18})\,\mathbf{a}_1 + (x_{18}+y_{18})\,\mathbf{a}_2 + z_{18}\,\mathbf{a}_3 = (ax_{18}+cz_{18}\cos\beta)\,\hat{\mathbf{x}} + by_{18}\,\hat{\mathbf{y}} + cz_{18}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XII}$$

$$\mathbf{B_{32}} = -(x_{18}+y_{18})\,\mathbf{a}_1 - (x_{18}-y_{18})\,\mathbf{a}_2 - z_{18}\,\mathbf{a}_3 = -(ax_{18}+cz_{18}\cos\beta)\,\hat{\mathbf{x}} + by_{18}\,\hat{\mathbf{y}} - cz_{18}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XII}$$

$$\mathbf{B_{33}} = (x_{19}-y_{19})\,\mathbf{a}_1 + (x_{19}+y_{19})\,\mathbf{a}_2 + z_{19}\,\mathbf{a}_3 = (ax_{19}+cz_{19}\cos\beta)\,\hat{\mathbf{x}} + by_{19}\,\hat{\mathbf{y}} + cz_{19}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIII}$$

$$\mathbf{B_{34}} = -(x_{19}+y_{19})\,\mathbf{a}_1 - (x_{19}-y_{19})\,\mathbf{a}_2 - z_{19}\,\mathbf{a}_3 = -(ax_{19}+cz_{19}\cos\beta)\,\hat{\mathbf{x}} + by_{19}\,\hat{\mathbf{y}} - cz_{19}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIII}$$

$$\mathbf{B_{35}} = (x_{20}-y_{20})\,\mathbf{a}_1 + (x_{20}+y_{20})\,\mathbf{a}_2 + z_{20}\,\mathbf{a}_3 = (ax_{20}+cz_{20}\cos\beta)\,\hat{\mathbf{x}} + by_{20}\,\hat{\mathbf{y}} + cz_{20}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIV}$$

$$\mathbf{B_{36}} = -(x_{20}+y_{20})\,\mathbf{a}_1 - (x_{20}-y_{20})\,\mathbf{a}_2 - z_{20}\,\mathbf{a}_3 = -(ax_{20}+cz_{20}\cos\beta)\,\hat{\mathbf{x}} + by_{20}\,\hat{\mathbf{y}} - cz_{20}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIV}$$

$$\mathbf{B_{37}} = (x_{21}-y_{21})\,\mathbf{a}_1 + (x_{21}+y_{21})\,\mathbf{a}_2 + z_{21}\,\mathbf{a}_3 = (ax_{21}+cz_{21}\cos\beta)\,\hat{\mathbf{x}} + by_{21}\,\hat{\mathbf{y}} + cz_{21}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XV}$$

$$\mathbf{B_{38}} = -(x_{21}+y_{21})\,\mathbf{a}_1 - (x_{21}-y_{21})\,\mathbf{a}_2 - z_{21}\,\mathbf{a}_3 = -(ax_{21}+cz_{21}\cos\beta)\,\hat{\mathbf{x}} + by_{21}\,\hat{\mathbf{y}} - cz_{21}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XV}$$

$$\mathbf{B_{39}} = (x_{22}-y_{22})\,\mathbf{a}_1 + (x_{22}+y_{22})\,\mathbf{a}_2 + z_{22}\,\mathbf{a}_3 = (ax_{22}+cz_{22}\cos\beta)\,\hat{\mathbf{x}} + by_{22}\,\hat{\mathbf{y}} + cz_{22}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVI}$$

$$\mathbf{B_{40}} = -(x_{22}+y_{22})\,\mathbf{a}_1 - (x_{22}-y_{22})\,\mathbf{a}_2 - z_{22}\,\mathbf{a}_3 = -(ax_{22}+cz_{22}\cos\beta)\,\hat{\mathbf{x}} + by_{22}\,\hat{\mathbf{y}} - cz_{22}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVI}$$

$$\mathbf{B_{41}} = (x_{23}-y_{23})\,\mathbf{a}_1 + (x_{23}+y_{23})\,\mathbf{a}_2 + z_{23}\,\mathbf{a}_3 = (ax_{23}+cz_{23}\cos\beta)\,\hat{\mathbf{x}} + by_{23}\,\hat{\mathbf{y}} + cz_{23}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVII}$$

$$\mathbf{B_{42}} = -(x_{23}+y_{23})\,\mathbf{a}_1 - (x_{23}-y_{23})\,\mathbf{a}_2 - z_{23}\,\mathbf{a}_3 = -(ax_{23}+cz_{23}\cos\beta)\,\hat{\mathbf{x}} + by_{23}\,\hat{\mathbf{y}} - cz_{23}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVII}$$

$$\mathbf{B_{43}} = (x_{24}-y_{24})\,\mathbf{a}_1 + (x_{24}+y_{24})\,\mathbf{a}_2 + z_{24}\,\mathbf{a}_3 = (ax_{24}+cz_{24}\cos\beta)\,\hat{\mathbf{x}} + by_{24}\,\hat{\mathbf{y}} + cz_{24}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVIII}$$

$$\mathbf{B_{44}} = -(x_{24}+y_{24})\,\mathbf{a}_1 - (x_{24}-y_{24})\,\mathbf{a}_2 - z_{24}\,\mathbf{a}_3 = -(ax_{24}+cz_{24}\cos\beta)\,\hat{\mathbf{x}} + by_{24}\,\hat{\mathbf{y}} - cz_{24}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XVIII}$$

$$\mathbf{B_{45}} = (x_{25}-y_{25})\,\mathbf{a}_1 + (x_{25}+y_{25})\,\mathbf{a}_2 + z_{25}\,\mathbf{a}_3 = (ax_{25}+cz_{25}\cos\beta)\,\hat{\mathbf{x}} + by_{25}\,\hat{\mathbf{y}} + cz_{25}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIX}$$

$$\mathbf{B_{46}} = -(x_{25}+y_{25})\,\mathbf{a}_1 - (x_{25}-y_{25})\,\mathbf{a}_2 - z_{25}\,\mathbf{a}_3 = -(ax_{25}+cz_{25}\cos\beta)\,\hat{\mathbf{x}} + by_{25}\,\hat{\mathbf{y}} - cz_{25}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XIX}$$

$$\mathbf{B_{47}} = (x_{26}-y_{26})\,\mathbf{a}_1 + (x_{26}+y_{26})\,\mathbf{a}_2 + z_{26}\,\mathbf{a}_3 = (ax_{26}+cz_{26}\cos\beta)\,\hat{\mathbf{x}} + by_{26}\,\hat{\mathbf{y}} + cz_{26}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XX}$$

$$\mathbf{B_{48}} = -(x_{26}+y_{26})\,\mathbf{a}_1 - (x_{26}-y_{26})\,\mathbf{a}_2 - z_{26}\,\mathbf{a}_3 = -(ax_{26}+cz_{26}\cos\beta)\,\hat{\mathbf{x}} + by_{26}\,\hat{\mathbf{y}} - cz_{26}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{O XX}$$

$$\mathbf{B_{49}} = (x_{27}-y_{27})\,\mathbf{a}_1 + (x_{27}+y_{27})\,\mathbf{a}_2 + z_{27}\,\mathbf{a}_3 = (ax_{27}+cz_{27}\cos\beta)\,\hat{\mathbf{x}} + by_{27}\,\hat{\mathbf{y}} + cz_{27}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V I}$$

$$\mathbf{B_{50}} = -(x_{27}+y_{27})\,\mathbf{a}_1 - (x_{27}-y_{27})\,\mathbf{a}_2 - z_{27}\,\mathbf{a}_3 = -(ax_{27}+cz_{27}\cos\beta)\,\hat{\mathbf{x}} + by_{27}\,\hat{\mathbf{y}} - cz_{27}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V I}$$

$$\mathbf{B_{51}} = (x_{28}-y_{28})\,\mathbf{a}_1 + (x_{28}+y_{28})\,\mathbf{a}_2 + z_{28}\,\mathbf{a}_3 = (ax_{28}+cz_{28}\cos\beta)\,\hat{\mathbf{x}} + by_{28}\,\hat{\mathbf{y}} + cz_{28}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V II}$$

$$\mathbf{B_{52}} = -(x_{28}+y_{28})\,\mathbf{a}_1 - (x_{28}-y_{28})\,\mathbf{a}_2 - z_{28}\,\mathbf{a}_3 = -(ax_{28}+cz_{28}\cos\beta)\,\hat{\mathbf{x}} + by_{28}\,\hat{\mathbf{y}} - cz_{28}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V II}$$

$$\mathbf{B_{53}} = (x_{29}-y_{29})\,\mathbf{a}_1 + (x_{29}+y_{29})\,\mathbf{a}_2 + z_{29}\,\mathbf{a}_3 = (ax_{29}+cz_{29}\cos\beta)\,\hat{\mathbf{x}} + by_{29}\,\hat{\mathbf{y}} + cz_{29}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V III}$$

$$\mathbf{B_{54}} = -(x_{29}+y_{29})\,\mathbf{a}_1 - (x_{29}-y_{29})\,\mathbf{a}_2 - z_{29}\,\mathbf{a}_3 = -(ax_{29}+cz_{29}\cos\beta)\,\hat{\mathbf{x}} + by_{29}\,\hat{\mathbf{y}} - cz_{29}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V III}$$

$$\mathbf{B_{55}} = (x_{30}-y_{30})\,\mathbf{a}_1 + (x_{30}+y_{30})\,\mathbf{a}_2 + z_{30}\,\mathbf{a}_3 = (ax_{30}+cz_{30}\cos\beta)\,\hat{\mathbf{x}} + by_{30}\,\hat{\mathbf{y}} + cz_{30}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V IV}$$

$$\mathbf{B_{56}} = -(x_{30}+y_{30})\,\mathbf{a}_1 - (x_{30}-y_{30})\,\mathbf{a}_2 - z_{30}\,\mathbf{a}_3 = -(ax_{30}+cz_{30}\cos\beta)\,\hat{\mathbf{x}} + by_{30}\,\hat{\mathbf{y}} - cz_{30}\sin\beta\,\hat{\mathbf{z}} \quad (4c) \quad \text{V IV}$$

References

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