| | | | | |
|---|---|---|---|---|
| termvar, x, y, d | Term-level variable | | | |
| *hole*, $h$ | ::= | | | Hole |
| term_value, v | ::= | | | Term value |
| | \| | $\langle \mathsf{v}_1 \,;\, \overline{\mathsf{v}_2} \rangle_{\mathsf{H}}$ | | Ampar |
| | \| | $@h$ | | Destination |
| | \| | $()$ | | Unit |
| | \| | $\mathbf{Inl}\ \mathsf{v}$ | | Left variant for sum |
| | \| | $\mathbf{Inr}\ \mathsf{v}$ | | Right variant for sum |
| | \| | $(\mathsf{v}_1 , \mathsf{v}_2)$ | | Product |
| | \| | $\lambda x . \mathsf{t}$ | | Linear function |
| | \| | $(\mathsf{v})$ | S | |
| $\overline{\text{extended\_value}}$, $\overline{\mathsf{v}}$ | ::= | | | Store value |
| | \| | $\mathsf{v}$ | | Term value |
| | \| | $h$ | | Hole |
| | \| | $\mathbf{Inl}\ \overline{\mathsf{v}}$ | | Left variant with val or hole |
| | \| | $\mathbf{Inr}\ \overline{\mathsf{v}}$ | | Right variant with val or hole |
| | \| | $(\overline{\mathsf{v}_1} , \overline{\mathsf{v}_2})$ | | Product with val or hole |
| | \| | $(\overline{\mathsf{v}})$ | S | |
| | \| | $\overline{\mathsf{v}}[e]$ | M | |
| term, t, u | ::= | | | Term |
| | \| | $\mathsf{v}$ | | Term value |
| | \| | $x$ | | Variable |
| | \| | $\mathsf{t}\ \mathsf{u}$ | | Application |
| | \| | $\mathsf{t} \succ \mathbf{case}\ () \mapsto \mathsf{u}$ | | Pattern-match on unit |
| | \| | $\mathsf{t} \succ \mathbf{case}\ \{ \mathbf{Inl}\ x_1 \mapsto \mathsf{u}_1 ,\ \mathbf{Inr}\ x_2 \mapsto \mathsf{u}_2 \}$ | | Pattern-match on sum |
| | \| | $\mathsf{t} \succ \mathbf{case}\ (x_1 , x_2) \mapsto \mathsf{u}$ | | Pattern-match on product |
| | \| | $\mathsf{t} \succ \mathbf{mapL}\ x \mapsto \mathsf{u}$ | | Map over the left side of the ampar |
| | \| | $\mathbf{to}_{\ltimes}\ \mathsf{t}$ | | Wrap t into a trivial ampar |
| | \| | $\mathbf{from}_{\ltimes}\ \mathsf{t}$ | | Extract value from trivial ampar |
| | \| | $\mathbf{alloc}_{\mathsf{A}}$ | | Return a fresh "identity" ampar object |
| | \| | $\mathsf{t} \triangleleft ()$ | | Fill destination with unit |
| | \| | $\mathsf{t} \triangleleft \mathbf{Inl}$ | | Fill destination with left variant |
| | \| | $\mathsf{t} \triangleleft \mathbf{Inr}$ | | Fill destination with right variant |
| | \| | $\mathsf{t} \triangleleft (,)$ | | Fill destination with product constructor |
| | \| | $\mathsf{t} \triangleleft\!\bullet\ \mathsf{u}$ | | Fill destination with root of ampar u |
| | \| | $(\mathsf{t})$ | S | |
| | \| | $\mathsf{t}[\mathsf{sub}]$ | M | |
| $\overline{\text{extended\_term}}$, $\overline{\mathsf{t}}$ | ::= | | | Extended term |
| | \| | $\mathsf{t}$ | | |
| | \| | $\overline{\mathsf{v}}$ | | |
| sub | ::= | | | Variable substitution |
| | \| | $x := \mathsf{v}$ | | |
| | \| | $\mathsf{sub}_1 , \mathsf{sub}_2$ | | |
| | \| | $\mathsf{sub}$ | S | |
| *effect*, $e$ | ::= | | | Effect |
| | \| | $\varepsilon$ | | No effect |
| | \| | $h := \overline{\mathsf{v}}$ | | |
| | \| | $e_1 \cdot e_2$ | | |

| | | | | |
|---|---|---|---|---|
| | $\mid$ | $e$ | S | |
| type, $A$, $B$ | ::= | | | Type |
| | $\mid$ | $1$ | | Unit |
| | $\mid$ | $A_1 \oplus A_2$ | | Sum |
| | $\mid$ | $A_1 \otimes A_2$ | | Product |
| | $\mid$ | $A_1 \rtimes A_2$ | | Ampar type (consuming $A_1$ yields $A_2$) |
| | $\mid$ | $A_1 \ {}_{m_1}\!\multimap A_2$ | | Linear function |
| | $\mid$ | $A^D$ | | Destination |
| | $\mid$ | $(A)$ | S | |
| mode, m | ::= | | | Mode |
| | $\mid$ | L | | Local |
| | $\mid$ | F | | Foreign |
| | $\mid$ | G | | Global |
| | $\mid$ | $\texttt{max\_mode}(\Gamma)$ | | |
| | $\mid$ | **if** mode_cond **then** $m_3$ **else** $m_4$ | | |
| mode_cond | ::= | | | Mode statement |
| | $\mid$ | $m_1 = m_2$ | | |
| | $\mid$ | $m \in$ **upper_modes** $(\Gamma)$ | | |
| | $\mid$ | $\exists m \in$ **upper_modes** $(\Gamma)$ | | |
| typing_context, $\Delta$ | ::= | | | Typing context |
| | $\mid$ | $\Gamma$ | | |
| | $\mid$ | $H$ | | |
| | $\mid$ | $\Gamma \sqcup H$ | | |
| pos_context, $\Gamma$ | ::= | | | Positive typing context |
| | $\mid$ | $\{\}$ | | |
| | $\mid$ | {pos_assigns} | | |
| | $\mid$ | $\Gamma_1 \sqcup \Gamma_2$ | | |
| | $\mid$ | $-H$ | | |
| | $\mid$ | $\Gamma[m_1 \mapsto m_2]$ | | |
| | $\mid$ | $(\Gamma)$ | S | |
| pos_assign, pa | ::= | | | Positive type assignment |
| | $\mid$ | $x :_m A$ | | |
| | $\mid$ | $+h : A$ | | Destination |
| pos_assigns | ::= | | | Positive type assignments |
| | $\mid$ | pa | | |
| | $\mid$ | pa, pos_assigns | | |
| neg_assign, na | ::= | | | Negative type assignment |
| | $\mid$ | $-h : A$ | | Hole |
| neg_assigns | ::= | | | Negative type assignments |
| | $\mid$ | na | | |
| | $\mid$ | na, neg_assigns | | |
| neg_context, $H$ | ::= | | | Negative typing context |
| | $\mid$ | $\{\}$ | | |

| | | | |
|---|---|---|---|
| | $\mid$ | $\{\mathsf{neg\_assigns}\}$ | |
| | $\mid$ | $\mathsf{H}_1 \sqcup \mathsf{H}_2$ | |
| | $\mid$ | $-\Gamma$ | |
| | $\mid$ | $(\mathsf{H})$ | S |
| terminals | ::= | | |
| | $\mid$ | $\multimap$ | |
| | $\mid$ | $\rtimes$ | |
| | $\mid$ | $\mapsto$ | |
| | $\mid$ | $()$ | |
| | $\mid$ | **Inl** | |
| | $\mid$ | **Inr** | |
| | $\mid$ | $(,)$ | |
| | $\mid$ | $\lhd$ | |
| | $\mid$ | $\lhd\!\bullet$ | |
| | $\mid$ | $\coloneqq$ | |
| | $\mid$ | $\sqcup$ | |
| | $\mid$ | $\uplus$ | |
| | $\mid$ | $\{\}$ | |
| | $\mid$ | $\exists$ | |
| | $\mid$ | $\neq$ | |
| | $\mid$ | $\leq$ | |
| | $\mid$ | $\in$ | |
| | $\mid$ | $\notin$ | |
| | $\mid$ | $\subset$ | |
| | $\mid$ | $\mathcal{N}$ | |
| | $\mid$ | $\vdash$ | |
| | $\mid$ | $\mid$ | |
| | $\mid$ | $\Downarrow$ | |
| formula | ::= | | |
| | $\mid$ | judgement | |
| Ctx | ::= | | |
| | $\mid$ | $\mathsf{x} \in \mathcal{N}(\Delta)$ | |
| | $\mid$ | $h \in \mathcal{N}(\Delta)$ | |
| | $\mid$ | $\mathsf{x} \notin \mathcal{N}(\Delta)$ | |
| | $\mid$ | $h \notin \mathcal{N}(\Delta)$ | |
| | $\mid$ | **fresh** $\mathsf{x}$ | |
| | $\mid$ | **fresh** $h$ | |
| | $\mid$ | $\mathsf{pos\_assign} \in \Gamma$ | |
| | $\mid$ | $\mathsf{neg\_assign} \in \mathsf{H}$ | |
| | $\mid$ | **onlyPositive** $(\Delta)$ | |
| | $\mid$ | **onlyNegative** $(\Delta)$ | |
| | $\mid$ | `mode_cond` | |
| Eq | ::= | | |
| | $\mid$ | $\mathbf{A}_1 = \mathbf{A}_2$ | |
| | $\mid$ | $\mathbf{A}_1 \neq \mathbf{A}_2$ | |
| | $\mid$ | $\mathsf{t} = \mathsf{u}$ | |
| | $\mid$ | $\mathsf{t} \neq \mathsf{u}$ | |
| | $\mid$ | $\Delta_1 = \Delta_2$ | |
| | $\mid$ | $\mathcal{N}(\Delta_1) \cap \mathcal{N}(\Delta_2) = \emptyset$ | |

| | | | |
|---|---|---|---|
| Eff | ::= | | |
| | \| | $e_2,\ \overline{\mathsf{v}_2}\ \mathsf{H}_2 = \mathbf{apply}(e_1,\ \overline{\mathsf{v}_1}\ \mathsf{H}_1)$ | Apply effect |
| Ty | ::= | | |
| | \| | $\Delta \vdash \bar{\mathsf{t}} : \mathbf{A}$ | |
| Sem | ::= | | |
| | \| | $\mathsf{t} \Downarrow \mathsf{t}' \mid e$ | |
| judgement | ::= | | |
| | \| | Ctx | |
| | \| | Eq | |
| | \| | Eff | |
| | \| | Ty | |
| | \| | Sem | |
| user_syntax | ::= | | |
| | \| | termvar | |
| | \| | *hole* | |
| | \| | term_value | |
| | \| | $\overline{\text{extended\_value}}$ | |
| | \| | term | |
| | \| | $\overline{\text{extended\_term}}$ | |
| | \| | sub | |
| | \| | *effect* | |
| | \| | **type** | |
| | \| | `mode` | |
| | \| | `mode_cond` | |
| | \| | typing_context | |
| | \| | pos_context | |
| | \| | pos_assign | |
| | \| | pos_assigns | |
| | \| | neg_assign | |
| | \| | neg_assigns | |
| | \| | neg_context | |
| | \| | terminals | |

$\boxed{\mathsf{x} \in \mathcal{N}(\Delta)}$

$\boxed{h \in \mathcal{N}(\Delta)}$

$\boxed{\mathsf{x} \notin \mathcal{N}(\Delta)}$

$\boxed{h \notin \mathcal{N}(\Delta)}$

$\boxed{\textbf{fresh}\ \mathsf{x}}$

$\boxed{\textbf{fresh}\ h}$

$\boxed{\text{pos\_assign} \in \Gamma}$

$\boxed{\text{neg\_assign} \in \mathsf{H}}$

$\boxed{\textbf{onlyPositive}\,(\Delta)}$

$\boxed{\textbf{onlyNegative}\,(\Delta)}$

$\boxed{\texttt{mode\_cond}}$

$\boxed{\mathbf{A}_1 = \mathbf{A}_2}$

$\boxed{\mathbf{A}_1 \neq \mathbf{A}_2}$

$\boxed{\mathsf{t} = \mathsf{u}}$

$\boxed{\mathsf{t} \neq \mathsf{u}}$

$\boxed{\Delta_1 = \Delta_2}$

$\boxed{\mathcal{N}(\Delta_1) \cap \mathcal{N}(\Delta_2) = \emptyset}$

$\boxed{e_2,\ \overline{\mathsf{v}_2}_{\,\mathsf{H}_2} = \mathbf{apply}(e_1,\ \overline{\mathsf{v}_1}_{\,\mathsf{H}_1})}$ Apply effect

$\boxed{\Delta \vdash \bar{\mathsf{t}} : \mathbf{A}}$

$$\frac{}{\{\} {\scriptstyle\sqcup} \{-h : \mathbf{A}\} \vdash h : \mathbf{A}}\ \textsc{TyTermExt\_Hole}$$

$$\frac{}{\{+h : \mathbf{A}\} {\scriptstyle\sqcup} \{\} \vdash @h : \mathbf{A}^{\mathbf{D}}}\ \textsc{TyTermExt\_Dest}$$

$$\frac{}{\{\} {\scriptstyle\sqcup} \{\} \vdash () : \mathbf{1}}\ \textsc{TyTermExt\_Unit}$$

$$\frac{\Gamma {\scriptstyle\sqcup} \mathsf{H} \vdash \overline{\mathsf{v}} : \mathbf{A}_1}{\Gamma {\scriptstyle\sqcup} \mathsf{H} \vdash \mathsf{Inl}\,\overline{\mathsf{v}} : \mathbf{A}_1 \oplus \mathbf{A}_2}\ \textsc{TyTermExt\_Inl}$$

$$\frac{\Gamma {\scriptstyle\sqcup} \mathsf{H} \vdash \overline{\mathsf{v}} : \mathbf{A}_2}{\Gamma {\scriptstyle\sqcup} \mathsf{H} \vdash \mathsf{Inr}\,\overline{\mathsf{v}} : \mathbf{A}_1 \oplus \mathbf{A}_2}\ \textsc{TyTermExt\_Inr}$$

$$\frac{\begin{array}{l}\Gamma_1 {\scriptstyle\sqcup} \mathsf{H}_1 \vdash \overline{\mathsf{v}_1} : \mathbf{A}_1 \\ \Gamma_2 {\scriptstyle\sqcup} \mathsf{H}_2 \vdash \overline{\mathsf{v}_2} : \mathbf{A}_2 \\ \mathcal{N}(\Gamma_1 {\scriptstyle\sqcup} \mathsf{H}_1) \cap \mathcal{N}(\Gamma_2 {\scriptstyle\sqcup} \mathsf{H}_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \mathsf{H}_1 \sqcup \mathsf{H}_2 \vdash (\overline{\mathsf{v}_1}\,,\,\overline{\mathsf{v}_2}) : \mathbf{A}_1 \otimes \mathbf{A}_2}\ \textsc{TyTermExt\_Prod}$$

$$\frac{\begin{array}{l}\Gamma_1 \sqcup -\mathsf{H} {\scriptstyle\sqcup} \{\} \vdash \mathsf{v}_1 : \mathbf{A}_1 \\ \Gamma_2 {\scriptstyle\sqcup} \mathsf{H} \vdash \overline{\mathsf{v}_2} : \mathbf{A}_2 \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \langle \mathsf{v}_1\,,\,\overline{\mathsf{v}_2}\rangle_{\mathsf{H}} : \mathbf{A}_1 \rtimes \mathbf{A}_2}\ \textsc{TyTermExt\_Ampar}$$

$$\frac{\Gamma \sqcup \{\mathsf{x} :_{\mathtt{m}_1} \mathbf{A}_1\} {\scriptstyle\sqcup} \{\} \vdash \mathsf{t} : \mathbf{A}_2}{\Gamma {\scriptstyle\sqcup} \{\} \vdash \lambda \mathsf{x}\,.\,\mathsf{t} : \mathbf{A}_1\ {}_{\mathtt{m}_1}\!\!\multimap \mathbf{A}_2}\ \textsc{TyTermExt\_Lambda}$$

$$\frac{\begin{array}{l}\Gamma_1 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t} : \mathbf{A}_1\ {}_{\mathtt{m}_1}\!\!\multimap \mathbf{A}_2 \\ \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{u} : \mathbf{A}_1 \\ \mathtt{m}_1 \in \mathbf{upper\_modes}\,(\Gamma_2) \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t}\ \mathsf{u} : \mathbf{A}_2}\ \textsc{TyTermExt\_App}$$

$$\frac{\begin{array}{l}\Gamma_1 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t} : \mathbf{1} \\ \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{u} : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t}\ \succ\!\mathbf{case}\ () \mapsto\ \mathsf{u} : \mathbf{B}}\ \textsc{TyTermExt\_PatUnit}$$

$$\frac{\begin{array}{l}\Gamma_1 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t} : \mathbf{A}_1 \oplus \mathbf{A}_2 \\ \exists\, \mathtt{m} \in \mathbf{upper\_modes}\,(\Gamma_1) \\ \Gamma_2 \sqcup \{\mathsf{x}_1 :_{\mathtt{m}} \mathbf{A}_1\} {\scriptstyle\sqcup} \{\} \vdash \mathsf{u}_1 : \mathbf{B} \\ \Gamma_2 \sqcup \{\mathsf{x}_2 :_{\mathtt{m}} \mathbf{A}_2\} {\scriptstyle\sqcup} \{\} \vdash \mathsf{u}_2 : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t}\ \succ\!\mathbf{case}\ \{\,\mathsf{Inl}\,\mathsf{x}_1 \mapsto \mathsf{u}_1\,,\ \mathsf{Inr}\,\mathsf{x}_2 \mapsto \mathsf{u}_2\,\} : \mathbf{B}}\ \textsc{TyTermExt\_PatSum}$$

$$\frac{\begin{array}{l}\Gamma_1 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t} : \mathbf{A}_1 \otimes \mathbf{A}_2 \\ \exists\, \mathtt{m} \in \mathbf{upper\_modes}\,(\Gamma_1) \\ \Gamma_2 \sqcup \{\mathsf{x}_1 :_{\mathtt{m}} \mathbf{A}_1, \mathsf{x}_2 :_{\mathtt{m}} \mathbf{A}_2\} {\scriptstyle\sqcup} \{\} \vdash \mathsf{u} : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 {\scriptstyle\sqcup} \{\} \vdash \mathsf{t}\ \succ\!\mathbf{case}\ (\mathsf{x}_1\,,\,\mathsf{x}_2) \mapsto\ \mathsf{u} : \mathbf{B}}\ \textsc{TyTermExt\_PatProd}$$

$$\frac{\begin{array}{l}\Gamma_1 \sqcup \{\} \vdash \mathsf{t} : \mathsf{A}_1 \rtimes \mathsf{A}_2 \\ \exists\, \mathtt{m}' \in \textsf{upper\_modes}\,(\Gamma_1 \sqcup \Gamma_2) \\ \mathtt{m} = \textsf{if}\ \mathtt{F} \in \textsf{upper\_modes}\,(\Gamma_1)\ \textsf{then}\ \mathtt{F}\ \textsf{else}\ \mathtt{L} \\ \Gamma_2[\mathtt{L} \mapsto \mathtt{F}] \sqcup \{\mathsf{x} :_{\mathtt{m}} \mathsf{A}_1\} \sqcup \{\} \vdash \mathsf{u} : \mathsf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset\end{array}}{\Gamma_1 \sqcup \Gamma_2 \sqcup \{\} \vdash \mathsf{t}\ \succ\!\textsf{mapL}\ \mathsf{x} \mapsto\ \mathsf{u} : \mathsf{B} \rtimes \mathsf{A}_2}\quad \textsc{TyTermExt\_MapAmpar}$$

$$\frac{}{\{\} \sqcup \{\} \vdash \textsf{alloc}_{\mathsf{A}} : \mathsf{A}^{\mathsf{D}} \rtimes \mathsf{A}}\quad \textsc{TyTermExt\_Alloc}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : \mathsf{A}}{\Gamma \sqcup \{\} \vdash \textsf{to}_{\rtimes}\ \mathsf{t} : \mathsf{1} \rtimes \mathsf{A}}\quad \textsc{TyTermExt\_ToAmpar}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : \mathsf{1} \rtimes \mathsf{A}}{\Gamma \sqcup \{\} \vdash \textsf{from}_{\rtimes}\ \mathsf{t} : \mathsf{A}}\quad \textsc{TyTermExt\_FromAmpar}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : \mathsf{1}^{\mathsf{D}}}{\Gamma \sqcup \{\} \vdash \mathsf{t} \lhd () : \mathsf{1}}\quad \textsc{TyTermExt\_FillUnit}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : (\mathsf{A}_1 \oplus \mathsf{A}_2)^{\mathsf{D}}}{\Gamma \sqcup \{\} \vdash \mathsf{t} \lhd \textsf{Inl} : {\mathsf{A}_1}^{\mathsf{D}}}\quad \textsc{TyTermExt\_FillInl}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : (\mathsf{A}_1 \oplus \mathsf{A}_2)^{\mathsf{D}}}{\Gamma \sqcup \{\} \vdash \mathsf{t} \lhd \textsf{Inr} : {\mathsf{A}_2}^{\mathsf{D}}}\quad \textsc{TyTermExt\_FillInr}$$

$$\frac{\Gamma \sqcup \{\} \vdash \mathsf{t} : (\mathsf{A}_1 \otimes \mathsf{A}_2)^{\mathsf{D}}}{\Gamma \sqcup \{\} \vdash \mathsf{t} \lhd (,) : {\mathsf{A}_1}^{\mathsf{D}} \otimes {\mathsf{A}_2}^{\mathsf{D}}}\quad \textsc{TyTermExt\_FillProd}$$

$$\frac{\begin{array}{l}\Gamma_1 \sqcup \{\} \vdash \mathsf{t} : {\mathsf{A}_2}^{\mathsf{D}} \\ \Gamma_2 \sqcup \{\} \vdash \mathsf{u} : \mathsf{A}_1 \rtimes \mathsf{A}_2 \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \\ \mathtt{L} \in \textsf{upper\_modes}\,(\Gamma_1) \\ \mathtt{F} \in \textsf{upper\_modes}\,(\Gamma_2)\end{array}}{\Gamma_1 \sqcup \Gamma_2 \sqcup \{\} \vdash \mathsf{t} \lhd\!\bullet\, \mathsf{u} : \mathsf{A}_1}\quad \textsc{TyTermExt\_FillCompL}$$

$$\frac{\begin{array}{l}\Gamma_1 \sqcup \{\} \vdash \mathsf{t} : {\mathsf{A}_2}^{\mathsf{D}} \\ \Gamma_2 \sqcup \{\} \vdash \mathsf{u} : \mathsf{A}_1 \rtimes \mathsf{A}_2 \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \\ \mathtt{F} \in \textsf{upper\_modes}\,(\Gamma_1) \\ \mathtt{G} \in \textsf{upper\_modes}\,(\Gamma_2)\end{array}}{\Gamma_1 \sqcup \Gamma_2 \sqcup \{\} \vdash \mathsf{t} \lhd\!\bullet\, \mathsf{u} : \mathsf{A}_1}\quad \textsc{TyTermExt\_FillCompF}$$

$\boxed{\mathsf{t} \Downarrow \mathsf{t}' \mid e}$

$$\frac{}{\mathsf{v} \Downarrow \mathsf{v} \mid \varepsilon}\quad \textsc{BigStep\_Val}$$

$$\frac{\begin{array}{l}\mathsf{t}_1 \Downarrow \lambda \mathsf{x}\,.\,\mathsf{u} \mid e_1 \\ \mathsf{t}_2 \Downarrow \mathsf{v}_2 \mid e_2 \\ \mathsf{u}[\mathsf{x} \coloneqq \mathsf{v}_2] \Downarrow \mathsf{v}_3 \mid e_3\end{array}}{\mathsf{t}_1\ \mathsf{t}_2 \Downarrow \mathsf{v}_3 \mid e_1 \cdot e_2 \cdot e_3}\quad \textsc{BigStep\_App}$$

$$\frac{\begin{array}{l}\mathsf{t}_1 \Downarrow () \mid e_1 \\ \mathsf{t}_2 \Downarrow \mathsf{v}_2 \mid e_2\end{array}}{\mathsf{t}_1\ \succ\!\textsf{case}\ () \mapsto\ \mathsf{t}_2 \Downarrow \mathsf{v}_2 \mid e_1 \cdot e_2}\quad \textsc{BigStep\_PatUnit}$$

$$\frac{\begin{array}{l}\mathsf{t} \Downarrow \textsf{Inl}\ \mathsf{v}_1 \mid e_1 \\ \mathsf{u}_1[\mathsf{x}_1 \coloneqq \mathsf{v}_1] \Downarrow \mathsf{v}_2 \mid e_2\end{array}}{\mathsf{t}\ \succ\!\textsf{case}\,\{\,\textsf{Inl}\ \mathsf{x}_1 \mapsto \mathsf{u}_1\,,\ \textsf{Inr}\ \mathsf{x}_2 \mapsto \mathsf{u}_2\,\} \Downarrow \mathsf{v}_2 \mid e_1 \cdot e_2}\quad \textsc{BigStep\_PatInl}$$

$$\frac{\begin{array}{l}\mathsf{t} \Downarrow \textsf{Inr}\ \mathsf{v}_1 \mid e_1 \\ \mathsf{u}_2[\mathsf{x}_2 \coloneqq \mathsf{v}_1] \Downarrow \mathsf{v}_2 \mid e_2\end{array}}{\mathsf{t}\ \succ\!\textsf{case}\,\{\,\textsf{Inl}\ \mathsf{x}_1 \mapsto \mathsf{u}_1\,,\ \textsf{Inr}\ \mathsf{x}_2 \mapsto \mathsf{u}_2\,\} \Downarrow \mathsf{v}_2 \mid e_1 \cdot e_2}\quad \textsc{BigStep\_PatInr}$$

$$\frac{\mathsf{t} \Downarrow (\mathsf{v}_1\,,\,\mathsf{v}_2) \mid e_1 \qquad \mathsf{u}[\mathsf{x}_1 := \mathsf{v}_1, \mathsf{x}_2 := \mathsf{v}_2] \Downarrow \mathsf{v}_2 \mid e_2}{\mathsf{t}\ \succ\mathbf{case}\,(\mathsf{x}_1\,,\,\mathsf{x}_2) \mapsto \mathsf{u} \Downarrow \mathsf{v}_2 \mid e_1 \cdot e_2} \quad \textsc{BigStep\_PatProd}$$

$$\frac{\mathsf{t} \Downarrow \langle \mathsf{v}_1\,{\scriptstyle{,}}\,\overline{\mathsf{v}_2}\rangle_{\mathsf{H}} \mid e_1 \qquad \mathsf{u}[\mathsf{x} := \mathsf{v}_1] \Downarrow \mathsf{v}_3 \mid e_2 \qquad e_3,\ \overline{\mathsf{v}_4}_{\,\mathsf{H}'} = \mathbf{apply}(e_1 \cdot e_2,\ \overline{\mathsf{v}_2}_{\,\mathsf{H}})}{\mathsf{t}\ \succ\mathbf{mapL}\,\mathsf{x} \mapsto \mathsf{u} \Downarrow \langle \mathsf{v}_3\,{\scriptstyle{,}}\,\overline{\mathsf{v}_4}\rangle_{\mathsf{H}'} \mid e_3} \quad \textsc{BigStep\_MapAmpar}$$

$$\frac{\mathbf{fresh}\ h}{\mathbf{alloc}_{\mathsf{A}} \Downarrow \langle @h\,{\scriptstyle{,}}\,h\rangle_{\{-h:\mathsf{A}\}} \mid \varepsilon} \quad \textsc{BigStep\_Alloc}$$

$$\frac{\mathsf{t} \Downarrow \mathsf{v} \mid e}{\mathbf{to}_{\ltimes}\ \mathsf{t} \Downarrow \langle ()\,{\scriptstyle{,}}\,\mathsf{v}\rangle_{\{\}} \mid e} \quad \textsc{BigStep\_ToAmpar}$$

$$\frac{\mathsf{t} \Downarrow \langle ()\,{\scriptstyle{,}}\,\mathsf{v}\rangle_{\{\}} \mid e}{\mathbf{from}_{\ltimes}\ \mathsf{t} \Downarrow \mathsf{v} \mid e} \quad \textsc{BigStep\_FromAmpar}$$

$$\frac{\mathsf{t} \Downarrow @h \mid e}{\mathsf{t} \triangleleft () \Downarrow () \mid e \cdot h := ()} \quad \textsc{BigStep\_FillUnit}$$

$$\frac{\mathsf{t} \Downarrow @h \mid e \qquad \mathbf{fresh}\ h'}{\mathsf{t} \triangleleft \mathsf{Inl} \Downarrow @h' \mid e \cdot h := \mathsf{Inl}\ h'} \quad \textsc{BigStep\_FillInl}$$

$$\frac{\mathsf{t} \Downarrow @h \mid e}{\mathsf{t} \triangleleft \mathsf{Inr} \Downarrow @h' \mid e \cdot h := \mathsf{Inr}\ h'} \quad \textsc{BigStep\_FillInr}$$

$$\frac{\mathsf{t} \Downarrow @h \mid e \qquad \mathbf{fresh}\ h_1 \qquad \mathbf{fresh}\ h_2}{\mathsf{t} \triangleleft (,) \Downarrow (@h_1\,,\,@h_2) \mid e \cdot h := (h_1\,,\,h_2)} \quad \textsc{BigStep\_FillProd}$$

$$\frac{\mathsf{t} \Downarrow @h \mid e_1 \qquad \mathsf{u} \Downarrow \langle \mathsf{v}_1\,{\scriptstyle{,}}\,\overline{\mathsf{v}_2}\rangle_{\mathsf{H}} \mid e_2}{\mathsf{t} \triangleleft\!\bullet \mathsf{u} \Downarrow \mathsf{v}_1 \mid e_1 \cdot e_2 \cdot h := \overline{\mathsf{v}_2}} \quad \textsc{BigStep\_FillComp}$$

```
Definition rules:         37 good    0 bad
Definition rule clauses: 109 good    0 bad
```