

<i>termvar</i> , <i>x</i> , <i>y</i> , <i>d</i>	Term-level variable	
<i>hole</i> , <i>h</i>	::=	Hole
<i>term_value</i> , <i>v</i>	::=	Term value
	$\langle v_1, \bar{v}_2 \rangle_H$	Ampar
	$@h$	Destination
	$()$	Unit
	$\text{Inl } v$	Left variant for sum
	$\text{Inr } v$	Right variant for sum
	(v_1, v_2)	Product
	$\lambda x. t$	Linear function
	(v)	S
$\overline{\text{extended_value}}$, \bar{v}	::=	Store value
	v	Term value
	h	Hole
	$\text{Inl } \bar{v}$	Left variant with val or hole
	$\text{Inr } \bar{v}$	Right variant with val or hole
	(\bar{v}_1, \bar{v}_2)	Product with val or hole
	(\bar{v})	S
	$\bar{v}[e]$	M
<i>term</i> , <i>t</i> , <i>u</i>	::=	Term
	v	Term value
	x	Variable
	$t \ u$	Application
	$t \succ \text{case } () \mapsto u$	Pattern-match on unit
	$t \succ \text{case } \{ \text{Inl } x_1 \mapsto u_1, \text{Inr } x_2 \mapsto u_2 \}$	Pattern-match on sum
	$t \succ \text{case } (x_1, x_2) \mapsto u$	Pattern-match on product
	$t \succ \text{mapL } x \mapsto u$	Map over the left side of the ampar
	$\text{to}_x t$	Wrap t into a trivial ampar
	$\text{from}_x t$	Extract value from trivial ampar
	alloc_A	Return a fresh "identity" ampar object
	$t \triangleleft ()$	Fill destination with unit
	$t \triangleleft \text{Inl}$	Fill destination with left variant
	$t \triangleleft \text{Inr}$	Fill destination with right variant
	$t \triangleleft (,)$	Fill destination with product constructor
	$t \triangleleft \bullet u$	Fill destination with root of ampar u
	(t)	S
	$t[\text{sub}]$	M
<i>sub</i>	::=	Variable substitution
	$x := v$	
	$\text{sub}_1, \text{sub}_2$	
	sub	S
<i>effect</i> , <i>e</i>	::=	Effect
	ε	No effect
	$h := \bar{v}$	
	$e_1 \cdot e_2$	
	e	S
<i>type</i> , <i>A</i> , <i>B</i>	::=	Type
	1	Unit

	$ \begin{array}{ l} \mathbf{A}_1 \oplus \mathbf{A}_2 \\ \mathbf{A}_1 \otimes \mathbf{A}_2 \\ \mathbf{A}_1 \ltimes \mathbf{A}_2 \\ \mathbf{A}_1 \multimap_{\mathbf{m}_1} \mathbf{A}_2 \\ \mathbf{A}^D \\ (\mathbf{A}) \end{array} $	Sum Product Ampar type (consuming \mathbf{A}_1 yields \mathbf{A}_2) Linear function Destination S
mode, \mathbf{m}	$ \begin{array}{ l} ::= \\ \mathbf{L} \\ \mathbf{F} \\ \mathbf{G} \\ \text{max_mode}(\Gamma) \\ \text{if mode_cond then } \mathbf{m}_3 \text{ else } \mathbf{m}_4 \end{array} $	Mode Local Foreign Global
mode_cond	$ \begin{array}{ l} ::= \\ \mathbf{m}_1 = \mathbf{m}_2 \\ \mathbf{m} \in \text{upper_modes}(\Gamma) \\ \exists \mathbf{m} \in \text{upper_modes}(\Gamma) \end{array} $	Mode statement
$\text{typing_context}, \Delta$	$ \begin{array}{ l} ::= \\ \Gamma \\ \mathbf{H} \\ \Gamma \sqcup \mathbf{H} \end{array} $	Typing context
$\text{pos_context}, \Gamma$	$ \begin{array}{ l} ::= \\ \{\} \\ \{\text{pos_assigns}\} \\ \Gamma_1 \sqcup \Gamma_2 \\ -\mathbf{H} \\ \Gamma[\mathbf{m}_1 \mapsto \mathbf{m}_2] \\ (\Gamma) \end{array} $	Positive typing context S
$\text{pos_assign}, \text{pa}$	$ \begin{array}{ l} ::= \\ \mathbf{x} :_{\mathbf{m}} \mathbf{A} \\ +\mathbf{h} : \mathbf{A} \end{array} $	Positive type assignment Destination
pos_assigns	$ \begin{array}{ l} ::= \\ \text{pa} \\ \text{pa}, \text{pos_assigns} \end{array} $	Positive type assignments
$\text{neg_assign}, \text{na}$	$ \begin{array}{ l} ::= \\ -\mathbf{h} : \mathbf{A} \end{array} $	Negative type assignment Hole
neg_assigns	$ \begin{array}{ l} ::= \\ \text{na} \\ \text{na}, \text{neg_assigns} \end{array} $	Negative type assignments
$\text{neg_context}, \mathbf{H}$	$ \begin{array}{ l} ::= \\ \{\} \\ \{\text{neg_assigns}\} \\ \mathbf{H}_1 \sqcup \mathbf{H}_2 \\ -\Gamma \\ (\mathbf{H}) \end{array} $	Negative typing context S

eff_app	$::=$ $ $ e, \bar{v}_H $ $ apply (eff_app) $ $ $e \hat{=} \text{eff_app}$	Effect application
terminals	$::=$ $ $ $\text{---}\circ$ $ $ \times $ $ \mapsto $ $ $()$ $ $ Inl $ $ Inr $ $ $(,)$ $ $ \triangleleft $ $ \blacktriangleleft $ $ $:=$ $ $ \sqcup $ $ \boxplus $ $ $\{\}$ $ $ \exists $ $ \neq $ $ \leq $ $ \in $ $ \notin $ $ \subset $ $ \mathcal{N} $ $ \vdash $ $ \Vdash $ $ $ $ $ $ \Downarrow	
formula	$::=$ $ $ judgement	
Ctx	$::=$ $ $ $x \in \mathcal{N}(\Delta)$ $ $ $h \in \mathcal{N}(\Delta)$ $ $ $x \notin \mathcal{N}(\Delta)$ $ $ $h \notin \mathcal{N}(\Delta)$ $ $ fresh x $ $ fresh h $ $ pos_assign $\in \Gamma$ $ $ neg_assign $\in H$ $ $ onlyPositive (Δ) $ $ onlyNegative (Δ) $ $ mode_cond	
Eq	$::=$ $ $ $A_1 = A_2$ $ $ $A_1 \neq A_2$ $ $ $t = u$ $ $ $t \neq u$ $ $ $\Delta_1 = \Delta_2$	

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

Ty ::=

- | $\Delta \Vdash e$
- | $\Gamma \vdash v \mid e : A$
- | $\Delta \Vdash \bar{v} : A$
- | $\Gamma \vdash t : A$

Sem ::=

- | $\text{eff_app}_1 = \text{eff_app}_2$ (we assume effect lists are ε -terminated)
- | $t \Downarrow v \mid e$

judgement ::=

- | Ctx
- | Eq
- | Ty
- | Sem

user_syntax ::=

- | *termvar*
- | *hole*
- | $\frac{\text{term_value}}{\text{extended_value}}$
- | term
- | sub
- | *effect*
- | **type**
- | *mode*
- | *mode_cond*
- | typing_context
- | pos_context
- | pos_assign
- | pos_assigns
- | neg_assign
- | neg_assigns
- | neg_context
- | eff_app
- | terminals

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

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

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

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

fresh x

fresh h

$$\text{pos_assign} \in \Gamma$$

$$\text{neg_assign} \in H$$

$$\text{onlyPositive}(\Delta)$$

$$\text{onlyNegative}(\Delta)$$

$$\text{mode_cond}$$

$$A_1 = A_2$$

$$\boxed{A_1 \neq A_2}$$

$$\boxed{t = u}$$

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

$$\boxed{\Delta_1 = \Delta_2}$$

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

$$\boxed{\Delta \Vdash e}$$

$$\frac{}{\{\} \sqcup \{\} \Vdash \varepsilon} \text{TYEFF_NOEFF}$$

$$\frac{\Gamma \sqcup H \Vdash \bar{v} : \mathbf{A} \quad h \notin \mathcal{N}(\Gamma)}{\Gamma \sqcup \{+h : \mathbf{A}\} \sqcup H \Vdash h := \bar{v}} \text{TYEFF_SINGLE}$$

$$\frac{\Gamma_1 \sqcup H_1 \sqcup H \Vdash e_1 \quad \Gamma_2 \sqcup -H \sqcup H_2 \Vdash e_2 \quad \mathcal{N}(\Gamma_1 \sqcup H_1) \cap \mathcal{N}(\Gamma_2 \sqcup H_2) = \emptyset}{\Gamma_1 \sqcup \Gamma_2 \sqcup H_1 \sqcup H_2 \Vdash e_1 \cdot e_2} \text{TYEFF_UNION}$$

$$\boxed{\Gamma \vdash v \mid e : \mathbf{A}}$$

$$\frac{\Gamma_1 \sqcup -H \vdash v : \mathbf{A} \quad \Gamma_2 \sqcup H \Vdash e \quad \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset}{\Gamma_1 \sqcup \Gamma_2 \vdash v \mid e : \mathbf{A}} \text{TYCMD_CMD}$$

$$\boxed{\Delta \Vdash \bar{v} : \mathbf{A}}$$

$$\frac{}{\{\} \sqcup \{-h : \mathbf{A}\} \Vdash h : \mathbf{A}} \text{TYVALEXT_HOLE}$$

$$\frac{}{\{+h : \mathbf{A}\} \sqcup \{\} \Vdash @h : \mathbf{A}^D} \text{TYVALEXT_DEST}$$

$$\frac{}{\{\} \sqcup \{\} \Vdash () : \mathbf{1}} \text{TYVALEXT_UNIT}$$

$$\frac{\Gamma \sqcup H \Vdash \bar{v} : \mathbf{A}_1}{\Gamma \sqcup H \Vdash \text{Inl } \bar{v} : \mathbf{A}_1 \oplus \mathbf{A}_2} \text{TYVALEXT_INL}$$

$$\frac{\Gamma \sqcup H \Vdash \bar{v} : \mathbf{A}_2}{\Gamma \sqcup H \Vdash \text{Inr } \bar{v} : \mathbf{A}_1 \oplus \mathbf{A}_2} \text{TYVALEXT_INR}$$

$$\frac{\Gamma_1 \sqcup H_1 \Vdash \bar{v}_1 : \mathbf{A}_1 \quad \Gamma_2 \sqcup H_2 \Vdash \bar{v}_2 : \mathbf{A}_2 \quad \mathcal{N}(\Gamma_1 \sqcup H_1) \cap \mathcal{N}(\Gamma_2 \sqcup H_2) = \emptyset}{\Gamma_1 \sqcup \Gamma_2 \sqcup H_1 \sqcup H_2 \Vdash (\bar{v}_1, \bar{v}_2) : \mathbf{A}_1 \otimes \mathbf{A}_2} \text{TYVALEXT_PROD}$$

$$\frac{-H \sqcup \{\} \Vdash v_1 : \mathbf{A}_1 \quad \Gamma_2 \sqcup H \Vdash \bar{v}_2 : \mathbf{A}_2}{\Gamma_2 \sqcup \{\} \Vdash \langle v_1, \bar{v}_2 \rangle_H : \mathbf{A}_1 \ltimes \mathbf{A}_2} \text{TYVALEXT_INCOMPLETEAMPAR}$$

$$\frac{\Gamma_1 \sqcup \{\} \Vdash v_1 : \mathbf{A}_1 \quad \Gamma_2 \sqcup \{\} \Vdash v_2 : \mathbf{A}_2 \quad \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset}{\Gamma_1 \sqcup \Gamma_2 \sqcup \{\} \Vdash \langle v_1, v_2 \rangle_{\{\}} : \mathbf{A}_1 \ltimes \mathbf{A}_2} \text{TYVALEXT_COMPLETEAMPAR} \quad (\text{behaves as a pair})$$

$$\frac{\Gamma \sqcup \{\times :_{m_1} \mathbf{A}_1\} \vdash t : \mathbf{A}_2}{\Gamma \sqcup \{\} \Vdash \lambda \times :_{m_1}. t : \mathbf{A}_1 \multimap \mathbf{A}_2} \text{TYVALEXT_LAMBDA}$$

$$\boxed{\Gamma \vdash t : \mathbf{A}}$$

$$\begin{array}{c}
\frac{\Gamma \sqcup \{\} \Vdash v : \mathbf{A}}{\Gamma \vdash v : \mathbf{A}} \quad \text{TYTERM_VAL} \\
\\
\frac{}{\{\mathbf{x} :_{\mathbf{m}} \mathbf{A}\} \vdash \mathbf{x} : \mathbf{A}} \quad \text{TYTERM_VAR} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{A}_1 \mathbf{m}_1 \multimap \mathbf{A}_2 \\ \Gamma_2 \vdash u : \mathbf{A}_1 \\ \mathbf{m}_1 \in \text{upper_modes}(\Gamma_2) \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash tu : \mathbf{A}_2} \quad \text{TYTERM_APP} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{1} \\ \Gamma_2 \vdash u : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash t \succ \text{case}() \mapsto u : \mathbf{B}} \quad \text{TYTERM_PATUNIT} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{A}_1 \oplus \mathbf{A}_2 \\ \exists \mathbf{m} \in \text{upper_modes}(\Gamma_1) \\ \Gamma_2 \sqcup \{\mathbf{x}_1 :_{\mathbf{m}} \mathbf{A}_1\} \vdash u_1 : \mathbf{B} \\ \Gamma_2 \sqcup \{\mathbf{x}_2 :_{\mathbf{m}} \mathbf{A}_2\} \vdash u_2 : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash t \succ \text{case} \{ \text{Inl } \mathbf{x}_1 \mapsto u_1, \text{Inr } \mathbf{x}_2 \mapsto u_2 \} : \mathbf{B}} \quad \text{TYTERM_PATSUM} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{A}_1 \otimes \mathbf{A}_2 \\ \exists \mathbf{m} \in \text{upper_modes}(\Gamma_1) \\ \Gamma_2 \sqcup \{\mathbf{x}_1 :_{\mathbf{m}} \mathbf{A}_1, \mathbf{x}_2 :_{\mathbf{m}} \mathbf{A}_2\} \vdash u : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash t \succ \text{case}(\mathbf{x}_1, \mathbf{x}_2) \mapsto u : \mathbf{B}} \quad \text{TYTERM_PATPROD} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{A}_1 \rtimes \mathbf{A}_2 \\ \exists \mathbf{m}' \in \text{upper_modes}(\Gamma_1 \sqcup \Gamma_2) \\ \mathbf{m} = \text{if } \mathbf{F} \in \text{upper_modes}(\Gamma_1) \text{ then } \mathbf{F} \text{ else } \mathbf{L} \\ \Gamma_2[\mathbf{L} \mapsto \mathbf{F}] \sqcup \{\mathbf{x} :_{\mathbf{m}} \mathbf{A}_1\} \vdash u : \mathbf{B} \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash t \succ \text{mapL } \mathbf{x} \mapsto u : \mathbf{B} \rtimes \mathbf{A}_2} \quad \text{TYTERM_MAPAMPAR} \\
\\
\frac{}{\{\} \vdash \text{alloc}_{\mathbf{A}} : \mathbf{A}^{\mathbf{D}} \rtimes \mathbf{A}} \quad \text{TYTERM_ALLOC} \\
\\
\frac{\Gamma \vdash t : \mathbf{A}}{\Gamma \vdash \text{to}_{\rtimes} t : \mathbf{1} \rtimes \mathbf{A}} \quad \text{TYTERM_TOAMPAR} \\
\\
\frac{\Gamma \vdash t : \mathbf{1} \rtimes \mathbf{A}}{\Gamma \vdash \text{from}_{\rtimes} t : \mathbf{A}} \quad \text{TYTERM_FROMAMPAR} \\
\\
\frac{\Gamma \vdash t : \mathbf{1}^{\mathbf{D}}}{\Gamma \vdash t \triangleleft () : \mathbf{1}} \quad \text{TYTERM_FILLUNIT} \\
\\
\frac{\Gamma \vdash t : (\mathbf{A}_1 \oplus \mathbf{A}_2)^{\mathbf{D}}}{\Gamma \vdash t \triangleleft \text{Inl} : \mathbf{A}_1^{\mathbf{D}}} \quad \text{TYTERM_FILLINL} \\
\\
\frac{\Gamma \vdash t : (\mathbf{A}_1 \oplus \mathbf{A}_2)^{\mathbf{D}}}{\Gamma \vdash t \triangleleft \text{Inr} : \mathbf{A}_2^{\mathbf{D}}} \quad \text{TYTERM_FILLINR} \\
\\
\frac{\Gamma \vdash t : (\mathbf{A}_1 \otimes \mathbf{A}_2)^{\mathbf{D}}}{\Gamma \vdash t \triangleleft (,) : \mathbf{A}_1^{\mathbf{D}} \otimes \mathbf{A}_2^{\mathbf{D}}} \quad \text{TYTERM_FILLPROD} \\
\\
\frac{\begin{array}{l} \Gamma_1 \vdash t : \mathbf{A}_2^{\mathbf{D}} \\ \Gamma_2 \vdash u : \mathbf{A}_1 \rtimes \mathbf{A}_2 \\ \mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \\ \mathbf{L} \in \text{upper_modes}(\Gamma_1) \\ \mathbf{F} \in \text{upper_modes}(\Gamma_2) \end{array}}{\Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft \bullet u : \mathbf{A}_1} \quad \text{TYTERM_FILLCOMPL}
\end{array}$$

$$\begin{array}{c}
\Gamma_1 \vdash t : \mathbf{A}_2^D \\
\Gamma_2 \vdash u : \mathbf{A}_1 \bowtie \mathbf{A}_2 \\
\mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset \\
\mathbf{f} \in \text{upper_modes}(\Gamma_1) \\
\mathbf{g} \in \text{upper_modes}(\Gamma_2) \\
\hline
\Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft_{\bullet} u : \mathbf{A}_1 \quad \text{TYTERM_FILLCOMP}
\end{array}$$

$$\boxed{\text{eff_app}_1 = \text{eff_app}_2}$$

(we assume effect lists are ε -terminated)

$$\frac{}{\text{apply}(\varepsilon, \bar{v}_H) = \varepsilon, \bar{v}_H} \text{EFFAPP_NOEFF}$$

$$\frac{h \notin \mathcal{N}(H)}{\text{apply}(h := \bar{v}' \cdot e, \bar{v}_H) = h := \bar{v}' \hat{\cdot} \text{apply}(e, \bar{v}_H)} \text{EFFAPP_SKIP}$$

$$\frac{}{\text{apply}(h := () \cdot e, \bar{v}_{H \sqcup \{-h:1\}}) = \text{apply}(e, \bar{v}[h := ()]_H)} \text{EFFAPP_FILLUNIT}$$

$$\frac{}{\text{apply}(h := \text{Inl } h' \cdot e, \bar{v}_{H \sqcup \{-h:\mathbf{A}_1 \oplus \mathbf{A}_2\}}) = \text{apply}(e, \bar{v}[h := \text{Inl } h']_{H \sqcup \{-h':\mathbf{A}_1\}})} \text{EFFAPP_FILLINL}$$

$$\frac{}{\text{apply}(h := \text{Inr } h' \cdot e, \bar{v}_{H \sqcup \{-h:\mathbf{A}_1 \oplus \mathbf{A}_2\}}) = \text{apply}(e, \bar{v}[h := \text{Inr } h']_{H \sqcup \{-h':\mathbf{A}_2\}})} \text{EFFAPP_FILLINR}$$

$$\frac{}{\text{apply}(h := (h_1, h_2) \cdot e, \bar{v}_{H \sqcup \{-h:\mathbf{A}_1 \otimes \mathbf{A}_2\}}) = \text{apply}(e, \bar{v}[h := (h_1, h_2)]_{H \sqcup \{-h_1:\mathbf{A}_1, -h_2:\mathbf{A}_2\}})} \text{EFFAPP_FILLPROD}$$

$$\begin{array}{c}
\Gamma' \sqcup H' \vdash \bar{v}' : \mathbf{A} \\
\mathcal{N}(H \sqcup \{-h:\mathbf{A}\}) \cap \mathcal{N}(H') = \emptyset \\
\hline
\text{apply}(h := \bar{v}' \cdot e, \bar{v}_{H \sqcup \{-h:\mathbf{A}\}}) = \text{apply}(e, \bar{v}[h := \bar{v}']_{H \sqcup H'}) \quad \text{EFFAPP_FILLCOMP} \quad (\text{Encompasses all other FILL rules})
\end{array}$$

$$\boxed{t \Downarrow v \mid e}$$

$$\frac{}{v \Downarrow v \mid \varepsilon} \text{BIGSTEP_VAL}$$

$$\begin{array}{c}
t_1 \Downarrow \lambda x. u \mid e_1 \\
t_2 \Downarrow v_2 \mid e_2 \\
u[x := v_2] \Downarrow v_3 \mid e_3 \\
\hline
t_1 t_2 \Downarrow v_3 \mid e_1 \cdot e_2 \cdot e_3 \quad \text{BIGSTEP_APP}
\end{array}$$

$$\begin{array}{c}
t_1 \Downarrow () \mid e_1 \\
t_2 \Downarrow v_2 \mid e_2 \\
\hline
t_1 \succ \text{case } () \mapsto t_2 \Downarrow v_2 \mid e_1 \cdot e_2 \quad \text{BIGSTEP_PATUNIT}
\end{array}$$

$$\begin{array}{c}
t \Downarrow \text{Inl } v_1 \mid e_1 \\
u_1[x_1 := v_1] \Downarrow v_2 \mid e_2 \\
\hline
t \succ \text{case } \{ \text{Inl } x_1 \mapsto u_1, \text{Inr } x_2 \mapsto u_2 \} \Downarrow v_2 \mid e_1 \cdot e_2 \quad \text{BIGSTEP_PATINL}
\end{array}$$

$$\begin{array}{c}
t \Downarrow \text{Inr } v_1 \mid e_1 \\
u_2[x_2 := v_1] \Downarrow v_2 \mid e_2 \\
\hline
t \succ \text{case } \{ \text{Inl } x_1 \mapsto u_1, \text{Inr } x_2 \mapsto u_2 \} \Downarrow v_2 \mid e_1 \cdot e_2 \quad \text{BIGSTEP_PATINR}
\end{array}$$

$$\begin{array}{c}
t \Downarrow (v_1, v_2) \mid e_1 \\
u[x_1 := v_1, x_2 := v_2] \Downarrow v_2 \mid e_2 \\
\hline
t \succ \text{case } (x_1, x_2) \mapsto u \Downarrow v_2 \mid e_1 \cdot e_2 \quad \text{BIGSTEP_PATPROD}
\end{array}$$

$$\begin{array}{c}
t \Downarrow \langle v_1, \bar{v}_2 \rangle_H \mid e_1 \\
u[x := v_1] \Downarrow v_3 \mid e_2 \\
e_3, \bar{v}_4 H' = \text{apply}(e_2, \bar{v}_2 H) \\
\hline
t \succ \text{mapL } x \mapsto u \Downarrow \langle v_3, \bar{v}_4 \rangle_{H'} \mid e_1 \cdot e_3 \quad \text{BIGSTEP_MAPAMPAR}
\end{array}$$

$$\begin{array}{c}
\text{fresh } h \\
\hline
\text{alloc}_{\mathbf{A}} \Downarrow \langle @h, h \rangle_{\{-h:\mathbf{A}\}} \mid \varepsilon \quad \text{BIGSTEP_ALLOC}
\end{array}$$

$$\begin{array}{c}
\frac{t \Downarrow v \mid e}{\mathbf{to}_{\times} t \Downarrow \langle (), v \rangle_{\{\}} \mid e} \quad \text{BIGSTEP_TOAMPAR} \\
\frac{t \Downarrow \langle (), v \rangle_{\{\}} \mid e}{\mathbf{from}_{\times} t \Downarrow v \mid e} \quad \text{BIGSTEP_FROMAMPAR} \\
\frac{t \Downarrow @h \mid e}{t \triangleleft () \Downarrow () \mid e \cdot h := ()} \quad \text{BIGSTEP_FILLUNIT} \\
\frac{t \Downarrow @h \mid e \quad \mathbf{fresh} \, h'}{t \triangleleft \text{Inl} \Downarrow @h' \mid e \cdot h := \text{Inl} \, h'} \quad \text{BIGSTEP_FILLINL} \\
\frac{t \Downarrow @h \mid e}{t \triangleleft \text{Inr} \Downarrow @h' \mid e \cdot h := \text{Inr} \, h'} \quad \text{BIGSTEP_FILLINR} \\
\frac{t \Downarrow @h \mid e \quad \mathbf{fresh} \, h_1 \quad \mathbf{fresh} \, h_2}{t \triangleleft (,) \Downarrow (@h_1, @h_2) \mid e \cdot h := (h_1, h_2)} \quad \text{BIGSTEP_FILLPROD} \\
\frac{t \Downarrow @h \mid e_1 \quad u \Downarrow \langle v_1, \overline{v_2} \rangle_H \mid e_2}{t \triangleleft \bullet u \Downarrow v_1 \mid e_1 \cdot e_2 \cdot h := \overline{v_2}} \quad \text{BIGSTEP_FILLCOMP}
\end{array}$$

Definition rules: 51 good 0 bad
 Definition rule clauses: 137 good 0 bad