1 構造規則

$$\frac{}{\Gamma, x : \tau;\quad \vdash x : \tau}\ \text{Int-Identity}$$

$$\frac{}{\Gamma; x : \tau \vdash x : \tau}\ \text{Lin-Identity}$$

$$\frac{\Gamma, y : \tau, x : \sigma, \Delta; \Xi \vdash z : \upsilon}{\Gamma, x : \sigma, y : \tau, \Delta; \Xi \vdash z : \upsilon}\ \text{Int-Exchange}$$

$$\frac{\Gamma; \Xi, y : \tau, x : \sigma, \Theta \vdash z : \upsilon}{\Gamma; \Xi, x : \sigma, y : \tau, \Theta \vdash z : \upsilon}\ \text{Lin-Exchange}$$

2 論理規則

$$\frac{\Gamma; \Xi \vdash e : \sigma}{\Gamma; \Xi, f : \sigma \multimap \tau \vdash f\ e : \tau}\ \multimap\text{-Left}$$

$$\frac{\Gamma; \Xi, x : \sigma \vdash e : \tau}{\Gamma; \Xi \vdash \lambda\ x :: \sigma\ .\ e : \sigma \multimap \tau}\ \multimap\text{-Right}$$

$$\frac{\Gamma; \Xi \vdash e : \tau}{\Gamma; \Xi, x : \mathit{unit} \vdash e : \tau}\ \mathit{unit}\text{-Left}$$

$$\frac{}{\Gamma;\ \ \vdash \langle\rangle : \mathit{unit}}\ \mathit{unit}\text{-Right}$$

$$\frac{\Gamma; \Xi, x_1 : \sigma_1, x_2 : \sigma_2 \vdash e : \tau}{\Gamma; \Xi, z : \sigma_1 \otimes \sigma_2 \vdash \mathit{let}\ z\ \mathit{be}\ \langle x_1, x_2\rangle\ \mathit{in}\ e : \tau}\ \otimes\text{-Left}$$

$$\frac{\Gamma; \Xi \vdash e_1 : \tau_1 \qquad \Gamma; \Theta \vdash e_2 : \tau_2}{\Gamma; \Xi, \Theta \vdash \langle e_1, e_2\rangle : \tau_1 \otimes \tau_2}\ \otimes\text{-Right}$$

$$\frac{\Gamma; \Xi, x_1 : \sigma_1 \vdash e_1 : \tau \qquad \Gamma; \Xi, x_2 : \sigma_2 \vdash e_2 : \tau}{\Gamma; \Xi, z : \sigma_1 \oplus \sigma_2 \vdash \mathit{case}\ z\ \mathit{of}\ \langle \mathit{inl}_{\sigma_2}\ x_1\rangle\ \Rightarrow\ e_1\ |\langle \mathit{inr}_{\sigma_1}\ x_2\rangle\ \Rightarrow\ e_2 : \tau}\ \oplus\text{-Left}$$

$$\frac{\Gamma; \Xi \vdash x : \tau_1}{\Gamma; \Xi \vdash \langle \mathit{inl}_{\tau_2}\ x\rangle : \tau_1 \oplus \tau_2}\ \oplus\text{-Right}_1$$

$$\frac{\Gamma; \Xi \vdash x : \tau_2}{\Gamma; \Xi \vdash \langle \mathit{inr}_{\tau_1}\ x\rangle : \tau_1 \oplus \tau_2}\ \oplus\text{-Right}_2$$

$$\frac{\Gamma, x : \sigma\ ; \Xi \vdash e : \tau}{\Gamma; \Xi, z :!\sigma \vdash \mathit{change}\ z\ \mathit{to}\ x\ \mathit{in}\ e : \tau}\ !\text{-Left}$$

$$\frac{\Gamma;\ \ \vdash x : \tau}{\Gamma;\ \ \vdash [x] :!\tau}\ !\text{-Right}$$

$$\frac{\Gamma;\ \ \vdash e :!\sigma \qquad \emptyset \diamond e \hookrightarrow v \qquad \{x \mapsto v\} \diamond \tau \hookrightarrow \tau'}{\Gamma; f : \Pi\ x ::!\sigma\ .\ \tau \vdash (f\ e) : \tau'}\ \Pi\text{-Left}$$

$$\frac{\Gamma, x : \sigma; \Xi \vdash e : \tau}{\Gamma; \Xi \vdash \Lambda\ x ::!\sigma\ .\ e : \Pi\ x ::!\sigma\ .\ \tau}\ \Pi\text{-Right}$$

$$\frac{}{\Gamma;\ \ \vdash \mathit{type} : \mathit{type}}\ \mathit{type}\text{-Type}$$

$$\frac{\Gamma;\ \ \vdash \sigma : \mathit{type} \qquad \Gamma;\ \ \vdash \tau : \mathit{type}}{\Gamma;\ \ \vdash \sigma \multimap \tau : \mathit{type}}\ \multimap\text{-Type}$$

$$\frac{}{\Gamma;\ \ \vdash \mathit{unit} : \mathit{type}}\ \mathit{unit}\text{-Type}$$

$$\frac{\Gamma;\ \ \vdash \tau_1 : \mathit{type} \qquad \cdots \qquad \Gamma;\ \ \vdash \tau_2 : \mathit{type}}{\Gamma;\ \ \vdash \tau_1 \otimes \tau_2 : \mathit{type}}\ \otimes\text{-Type}$$

$$\frac{\Gamma;\ \ \vdash \tau_1 : \mathit{type} \qquad \cdots \qquad \Gamma;\ \ \vdash \tau_2 : \mathit{type}}{\Gamma;\ \ \vdash \tau_1 \oplus \tau_2 : \mathit{type}}\ \oplus\text{-Type}$$

$$\frac{\Gamma;\ \ \vdash \tau : \mathit{type}}{\Gamma;\ \ \vdash\ !\tau : \mathit{type}}\ !\text{-Type}$$

$$\frac{\Gamma, x : \sigma\ ;\ \ \vdash \tau : \mathit{type}}{\Gamma;\ \ \vdash \Pi\ x ::!\sigma\ .\ \tau : \mathit{type}}\ \Pi\text{-Type}$$

3 評価規則

$$\frac{\varsigma_f \diamond f \hookrightarrow \lambda\, x :: \sigma\, .\, e' \qquad \varsigma_e \diamond e \hookrightarrow v' \qquad v' \bowtie x \rightsquigarrow \varsigma_x \qquad \varsigma_x \diamond e \hookrightarrow v}{\varsigma_f \uplus \varsigma_e \diamond f\ e \hookrightarrow v}\ \multimap\text{-C}$$

$$\frac{\varsigma_{in} \diamond z \hookrightarrow \langle v_1, v_2 \rangle \qquad \langle v_1, v_2 \rangle \bowtie \langle x_1, x_2 \rangle \rightsquigarrow \varsigma_{out} \qquad \varsigma_{out} \uplus \varsigma_e \diamond e \hookrightarrow v}{\varsigma_{in} \uplus \varsigma_e \diamond let\ z\ be\ \langle x_1, x_2 \rangle\ in\ e \hookrightarrow v}\ \otimes\text{-C}$$

$$\frac{\varsigma_{in} \diamond z \hookrightarrow \langle inl_{\sigma_2}\ v' \rangle \qquad v' \bowtie x_1 \rightsquigarrow \varsigma_{out} \qquad \varsigma_{out} \uplus \varsigma_e \diamond e \hookrightarrow v}{\varsigma_{in} \uplus \varsigma_e \diamond case\ z\ of\ \langle inl_{\sigma_2}\ x_1 \rangle\ \Rightarrow\ e_1\ |\langle inr_{\sigma_1}\ x_2 \rangle\ \Rightarrow\ e_2 \hookrightarrow v}\ \oplus\text{-C}_1$$

$$\frac{\varsigma_{in} \diamond z \hookrightarrow \langle inr_{\sigma_1}\ v' \rangle \qquad v' \bowtie x_2 \rightsquigarrow \varsigma_{out} \qquad \varsigma_{out} \uplus \varsigma_e \diamond e \hookrightarrow v}{\varsigma_{in} \uplus \varsigma_e \diamond case\ z\ of\ \langle inl_{\sigma_2}\ x_1 \rangle\ \Rightarrow\ e_1\ |\langle inr_{\sigma_1}\ x_2 \rangle\ \Rightarrow\ e_2 \hookrightarrow v}\ \oplus\text{-C}_2$$

$$\frac{\varsigma_{in} \diamond z \hookrightarrow [v'] \qquad v' \bowtie x \rightsquigarrow \varsigma_{out} \qquad \varsigma_{out} \uplus \varsigma_e \diamond e \hookrightarrow v}{\varsigma_{in} \uplus \varsigma_e \diamond change\ z\ to\ x\ in\ e \hookrightarrow v}\ !\text{-C}$$

$$\frac{\varsigma_f \diamond f \hookrightarrow \Lambda\, x ::!\sigma\, .\, e' \qquad \varsigma_e \diamond e \hookrightarrow v' \qquad v' \bowtie x \rightsquigarrow \varsigma_x \qquad \varsigma_x \diamond e \hookrightarrow v}{\varsigma_f \uplus \varsigma_e \diamond f\ e \hookrightarrow v}\ \Pi\text{-C}$$

$$\frac{\varsigma_1 \diamond \sigma \hookrightarrow \nu_1 \qquad \varsigma_2 \diamond \tau \hookrightarrow \nu_2}{\varsigma_1 \uplus \varsigma_2 \diamond \sigma \multimap \tau \hookrightarrow \nu_1 \multimap \nu_2}\ \multimap\text{-Type-C}$$

$$\frac{\varsigma_1 \diamond \tau_1 \hookrightarrow \nu_1 \qquad \varsigma_2 \diamond \tau_2 \hookrightarrow \nu_2}{\varsigma_1 \uplus \varsigma_2 \diamond \tau_1 \otimes \tau_2 \hookrightarrow \nu_1 \otimes \nu_2}\ \otimes\text{-Type-C}$$

$$\frac{\varsigma_1 \diamond \tau_1 \hookrightarrow \nu_1 \qquad \varsigma_2 \diamond \tau_2 \hookrightarrow \nu_2}{\varsigma_1 \uplus \varsigma_2 \diamond \tau_1 \oplus \tau_2 \hookrightarrow \nu_1 \oplus \nu_2}\ \oplus\text{-Type-C}$$

$$\frac{\Gamma; \Xi, w : \mu\ x\ .\ \sigma \vdash e : \tau}{\Gamma; \Xi, z : \mu\ x\ .\ \sigma[\mu\ x\ .\ \sigma/x] \vdash unfold\ z\ as\ w\ in\ e : \tau}\ \mu\text{-L}$$

$$\frac{\Gamma; \Xi \vdash e : \tau[\mu\ x.\ \tau/x]}{\Gamma; \Xi \vdash fold\ e : \mu\ x\ .\ \tau}\ \mu\text{-R}$$

$$\frac{\Gamma, x : type; \quad \vdash \tau : type}{\Gamma; \quad \vdash \mu\ x\ .\ \tau : type}\ \mu\text{-Type}$$

$$\frac{\Gamma; \Xi, x_1 : \sigma \vdash e_1 : \tau \oplus \chi \qquad \Gamma; \Xi, x_2 : \chi \vdash e_2 : \tau \oplus \chi}{\Gamma; \Xi, x : \sigma \vdash trace\ x\ of\ \langle inl_\chi\ x_1 \rangle\ \Rightarrow\ e_1\ |\langle inr_\sigma\ x_2 \rangle\ \Rightarrow\ e_2 : \tau}\ \text{trace}$$