

$$I, \Gamma \vdash_p \text{pgm} : \tau$$

Program Typing

$$\frac{I; \Gamma \vdash_{tm} \text{expr} : \tau}{I, \Gamma \vdash_p \text{expr} : \tau} \text{EXPRESSION}$$

$$\frac{I, \Gamma \vdash_i \text{impl} : I' \quad I', \Gamma \vdash_p \text{pgm} : \tau}{I, \Gamma \vdash_p \text{impl}; \text{pgm} : \tau} \text{IMPLICIT}$$

$$\frac{I, \Gamma \vdash_d \text{data} : \Gamma' \quad I, \Gamma' \vdash_p \text{pgm} : \tau}{I, \Gamma \vdash_p \text{impl}; \text{pgm} : \tau} \text{DATA}$$

$$I, \Gamma \vdash_i \text{impl} : I'$$

Building the Implicit Environment

$$\frac{I; \Gamma \vdash_{tm} \text{expr} : \tau_1 \rightarrow \tau_2}{I, \Gamma \vdash_i \text{implicit } i : \tau_1 \rightsquigarrow \tau_2 = \text{expr} : I, i}$$

$$I, \Gamma \vdash_d \text{impl} : I'$$

Building the Typing Environment

$$I, \Gamma \vdash_d (\text{data } T \text{ } a = K \bar{\tau}) : \Gamma, T, (K : \forall a. \bar{\tau} \rightarrow T \text{ } a)$$

$$I; \Gamma \vdash_{tm} e : \tau$$

$$\frac{I; \Gamma \vdash_{tm} e : \tau; *, *, e'}{I; \Gamma \vdash_{tm} e : \tau}$$

$$I; \Gamma \vdash_{tm} e : \tau; E; Y; e'$$

Type Inference and Partial Translation

$$\frac{(x : \tau) \in \Gamma}{I; \Gamma \vdash_{tm} x : \tau; \bullet; \bullet; x} \text{VAR} \quad \frac{(K : \forall a. \tau) \in \Gamma}{I; \Gamma \vdash_{tm} K : [a \mapsto \tau']\tau; \bullet; \bullet; K} \text{CONSTR}$$

$$\frac{I; \Gamma, x : a \vdash_{tm} e : \tau; E; Y; e'}{I; \Gamma \vdash_{tm} \lambda x. e : a \rightarrow \tau; E; Y; e'} \text{ABSTRACTION}$$

$$\frac{\begin{array}{c} I; \Gamma \vdash_{tm} e_1 : \tau_1; E_1; Y_1; e'_1 \\ I; \Gamma \vdash_{tm} e_2 : \tau_2; E_2; Y_2; e'_2 \quad \text{fresh } j \end{array}}{I; \Gamma \vdash_{tm} e_1 e_2 : a; E_1 + E_2 + (\tau_1 \sim b \rightarrow a); Y_1 + Y_2 + I \models_i j : \tau_2 \rightsquigarrow b; e'_1(j \text{ } e'_2)} \text{APPLICATION}$$

$$\frac{\begin{array}{c} (K : \forall a. \bar{\tau} \rightarrow T \text{ } a) \in \Gamma \quad I; \Gamma \vdash_{tm} e_1 : \tau_1; E_1; Y_1; e'_1 \\ I; \Gamma, \bar{x} : [a \mapsto b]\bar{\tau} \vdash_{tm} e_2 : \tau_2; E_2; Y_2; e'_2 \quad \text{fresh } j \end{array}}{I; \Gamma \vdash_{tm} \text{case } e_1 \text{ of } (K \text{ } x) \rightarrow e_2 : \tau_2; E_1 + E_2; Y_1 + Y_2 + I \models_i j : \tau_1 \rightsquigarrow T \text{ } b; \text{case } (j \text{ } e'_1) \text{ of } (K \text{ } x) \rightarrow e'_2} \text{CASE}$$

$$I \models_i j : \tau_1 \rightsquigarrow \tau_2; \Theta; \varphi$$

Implicit Conversion Resolution and Subst

$$\frac{\bullet; I \models_i j : \tau_1 \rightsquigarrow \tau_2; \Theta; \varphi}{I \models_i j : \tau_1 \rightsquigarrow \tau_2; \Theta; \varphi} \text{AUX}$$

$$\boxed{\bar{\tau}; I \models_i j : \tau_1 \rightsquigarrow \tau_2; \Theta; \varphi}$$

Implicit Conversion Resolution with Loop Detection

$$\frac{[fv(\tau_1) \mapsto \bar{\tau}_{1i}] \tau_1 = [fv(\tau_2) \mapsto \bar{\tau}_{2i}] \tau_2}{\bar{\tau}; I \models_i j : \tau_1 \rightsquigarrow \tau_2; [j \mapsto id]; [fv(\tau_1) \mapsto \bar{\tau}_{1i}, fv(\tau_2) \mapsto \bar{\tau}_{2i}]} \text{UNIFICATION}$$

$$\frac{\begin{array}{l} (\forall \bar{a}. Cond \Rightarrow \tau'_1 \rightsquigarrow \tau'_3 = expr_{fst}) \in I \\ \tau_1 = [\bar{a} \mapsto \bar{\tau}_a] \tau'_1 \quad \tau_3 = [\bar{a} \mapsto \bar{\tau}_a] \tau'_3 \quad \tau_3 \notin \bar{\tau} \\ \forall cond_i \in [\bar{a} \mapsto \bar{\tau}_a] Cond : (I \models_i cond_i : \tau_{i1} \rightsquigarrow \tau_{i2}; \Theta_i; \varphi_i) \\ \bar{\tau}, \tau_1; I \models_i conv_{rest} : (\bar{\varphi}_i \tau_3) \rightsquigarrow \tau_2; \Theta_{rest}; \varphi_{rest} \end{array}}{\bar{\tau}; I \models_i conv : \tau_1 \rightsquigarrow \tau_2; [conv \mapsto (\Theta_{rest} conv_{rest}) \circ (\bar{\Theta}_i ([\bar{a} \mapsto \bar{\tau}_a] expr_{fst}))]; \varphi_{rest} \circ \bar{\varphi}_i \circ [\bar{a} \mapsto \bar{\tau}_a]} \text{TRANSITIVITY}$$

\* ::= If all the constraints have been satisfied.