Encoding

```
Let summate' = Function self → Function n →
    If n=0 Then 0 Else self self (n-1) + n
In
Let summate = summate' summate' In
summate 5
```

```
Let yc =
    Function f →
        Let wrapper = Function self → Function arg →
                          f (self self) arg
        In
        wrapper wrapper
In
Let summate = yc (Function recurse → Function n →
                      If n=0 Then 0 Else recurse (n-1) + n)
In
summate 5
```

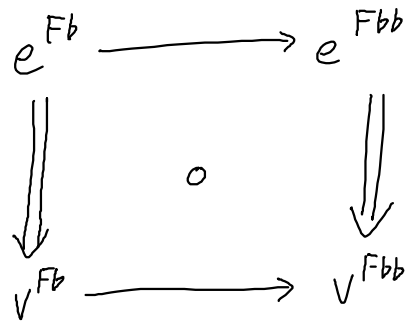
Fbb : exactly Fb w/o Let

$$\frac{e_1 \Rightarrow v_1 \qquad e_2[v_1/x] \Rightarrow v_2}{\text{Let } x = e_1 \text{ In } e_2 \Rightarrow v_2}$$

$F(e^{Fb}) \to e^{Fbb}$

$F(4) = 4$

$F(e_1 + e_2) = F(e_1) + F(e_2)$



$F(\text{Let } x = e_1 \text{ In } e_2) = (\text{Function } x \to F(e_2))\ (F(e_1))$

FbP — Fb with pairs

$e ::= \ldots \mid (e, e) \mid \text{Fst } e \mid \text{Snd } e$

$v ::= \ldots \mid (v, v)$

$$\frac{e_1 \Rightarrow v_1 \quad e_2 \Rightarrow v_2}{(e_1, e_2) \Rightarrow (v_1, v_2)}$$

$e \Rightarrow v$

$$\frac{e \Rightarrow (v_1, v_2)}{\text{Fst } e \Rightarrow v_1}$$

Fst (1+1, 3+4)

$$\frac{e \Rightarrow (v_1, v_2)}{\text{Snd } e \Rightarrow v_2}$$

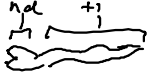
$F(e^{FbP}) \rightarrow e^{Fb}$

$F((e_1, e_2)) =$ Let $x_1 = F(e_1)$ In
Let $x_2 = F(e_2)$ In
Function b → If b Then x_1 Else x_2

$F(\text{Fst } e) = F(e)$ True

$F(\text{Snd } e) = F(e)$ False

Fst (1+2, 3+False) =/=>



FbL — Fb with lists

e ::= ... | Nil | Cons e e | Hd e | Tl e

v ::= ... | Nil | Cons v v

$F(e^{FbL}) \rightarrow e^{FbP}$

$$F(Nil) = (False, 0)$$

$$F(Cons\ e_1\ e_2) = (True, (F(e_1), F(e_2)))$$