Preflight #5

We discussed in class processes mediated by the weak force where Strangeness changes, e.g. $\bar{K}^0(\bar{d}s) \to \Pi^+(\bar{d}u)e^-\bar{\nu}_e$. We understood this process as a transition from a s-quark to an u-quark by emitting a W^-: $s \to u + W^-$, where $W^\pm$ is the charged mediator of the weak force. The corresponding charged weak current is described by the quark isospin doublet

$$\begin{pmatrix} u \\ d' \end{pmatrix}$$

so that the weak current reads (γ_μ and γ_5 are 4×4 matrices; their exact form is not important for this discussion)

$$\bar{u}\gamma_\mu(1-\gamma_5)d'$$

With $d' = d\cos\theta_C + s\sin\theta_C$ one finds

$$\bar{u}\gamma_\mu(1-\gamma_5)d\cos\theta_C + \bar{u}\gamma_\mu(1-\gamma_5)s\sin\theta_C$$

In this way you can have $u \Leftrightarrow d$ and $u \Leftrightarrow s$ transitions. Consider now weak processes, where the charge of the quark does not change, e.g. $u \Leftrightarrow u$ transitions.

These processes take place via a neutral weak force mediator, the Z^0 boson, and the corresponding neutral weak current reads (v, a are real numbers)

$$\bar{u}\gamma_\mu(v - a\gamma_5)u + \bar{d}'\gamma_\mu(v - a\gamma_5)d'$$

with $d' = d\cos\theta_C + s\sin\theta_C$.

(a) Under these assumptions can the decay $K^-(s\bar{u}) \to \Pi^-(d\bar{u})e^+e^-$ happen ?
(b) What if I tell you that this decay has not been observed ?
What will happen, if you assume the existence of a forth quark, c, so that there is a second quark doublet

$$\begin{pmatrix} c \\ s' \end{pmatrix}$$

with $s' = -d\sin\theta_C + s\cos\theta_C$. It is an exact copy of the (u,d') doublet but the c, s quarks are heavier than the u, d quarks. How does the neutral weak current change ? Can you now explain why this decay has not been observed ?