DEPARTMENT OF PHYSICS
OSAKA IMPERIAL UNIVERSITY.

DATE
NO.

Dear Prof. John T. Tate

was stated

Your letter, in which ~~states~~ the disapproval of the publication of my letter on the "Density Matrix in the Theory of the Positron" in the Physical Review, received a few days ago. I am very sorry to have troubled you with this matter, but on the other hand, I regret to find that the opinion of the referee started from serious misunderstanding of certain points ~~the content~~ of my letter.

Therefore I feel it necessary to given on the referee reply ~~on this occasion~~ to ~~give an account of its essential points~~ on the point at issue.

I shall feel much obliged if you will kindly deliver ~~hand over this letter~~ the reply to the referee.

For purposes of reference, my previous letter with a few addition ~~in question~~ is again enclosed. I hope that the Editors will recognize its due value, however small it may be.

Yours truly,
Hideki Yukawa

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Reply to the Comments of the Referee in (5) or (5') in my previous letter

The wave functions can be written in the form

$$\psi_n(x,k) = u_{n,k}\, e^{\frac{i}{\hbar}(\vec{p}_n\vec{r} - W_n t)}$$

for the case $V=0$ and $\vec{A}=0$. In empty space, the summation $\sum_{occ}$ should be made for all ~~values~~ ~~of positive~~ the negative energy ($W_n \leq 0$), while $\sum_{unocc}$ for all ~~values of n~~ the positive energy state ($W_n > 0$). Now, if we take ψ_n instead of ψ_n^* in $\sum_{occ}$, both the energy and the momentum change~~s~~ their signs, so that (5) becomes

$$\frac{1}{2}\Big\{\sum_{W_n>0} \psi_n(x'k')\psi_n^*(xk) - \sum_{W_n>0} \psi_n^*(x'k')\psi_n(xk)\Big\} \quad (5,1)$$

which is zero for any set of values of $(x,k;x',k')$, as two summations are identical. On the other hand (5') becomes by the same procedure

$$\frac{1}{2}\Big\{\sum_{W_n>0} \psi_n(x'k')\psi_n^*(x,k) - \sum_{W_n>0} \psi_n^*(x'k')\psi_n(x,k)\Big\} \quad (5,1)'$$

If ~~we put~~ we put $t=t'$ in (5,1)', ~~at the beginning~~ it becomes 0, as in (5,1), ~~two summations in this expression~~ can be identified by mere relabelling, while, if $t \neq t'$, corresponding terms in ~~them~~ two summations have time factors

$$e^{-\frac{iW_n}{\hbar}(t'-t)} \quad \text{and} \quad e^{\frac{iW_n}{\hbar}(t'-t)}$$

respectively, so that the limitting value~~s~~ of (5)'

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$(t'-t)^2 - c^2(\vec{r}'-\vec{r})^2 = +0$

for $t'-t=+0$ ~~are $t'-t=-0$ are~~ is not zero and not ~~#~~ coincides with that for $t'-t=-0$, as shown by Dirac in detail. Thus $t=t'$ (more generally $c^2(t-t')^2-(\vec{r}-\vec{r}')^2=0$) becomes singular region of Dirac's density matrix

for $s^2 = (t'-t)^2 - c^2(\vec{r}'-\vec{r})^2 = 0$ becomes infinity of order ~~$\frac{1}{(t'-t)}$~~ ~~s^4~~ s^{-2}, as shown by Dirac in detail.

Thus ~~the~~ the main ~~point~~ result of ~~my letter~~ was ~~that~~ we ~~could~~ find everywhere vanishing density matrix for empty space ~~without~~, which ~~makes~~ made the subtraction technique superfluous, in which is ~~the~~ the departure from ~~the~~ Dirac's formulation. ~~contrast to Dirac's theory.~~

~~In the presence of the field~~ Such a simple procedure, however, can not get rid of the difficulty in the presence of the ~~field~~ external field, so that ~~I do not pretend~~ never ~~to have made a thorough success~~
~~my modification~~ I do not deny but that my modification may ~~be~~ be only trivial. It will be left ~~I leave~~ it to your judgement whether or not ~~such a~~ ~~Such~~ this modification is trivial.