$\lambda = \frac{h}{p}$ where $p = mv$ h = planck constant

Should apply to any particle, even massive ones (such as a ball moving through space)

Both methods of deriving this lead to Contradiction.

$\boxed{\text{Method 1:}}$ For an electromagnetic wave:

$$E = hf = h\frac{c}{\lambda}$$ f = frequency

(A) The assumption is that for particles, $E = hf$ as well.

Additionally, $E = mc^2$

(B) $mc^{\cancel{2}} = h\frac{\cancel{c}}{\lambda}$

$$\lambda = \frac{h}{mc}$$

but for particles not travelling at c, we can substitute c for v.

$$\lambda = \frac{h}{mv}$$

The problem is that, even if assumption (A) is correct, the substitution is made too early. It would have to be done at (B)

$$mv^2 = h\frac{v}{\lambda}$$ note: $\frac{v}{\lambda} = f$ still

The problem is that mv^2 is meaningless, It no longer means energy, since $E = mc^2$ regardless of velocity. (Note, v is not large, so kinetic energy is negligible, hence $E = mc^2$ and not $mc^2 + \frac{1}{2}mv^2$)

So thus, $mv^2 \neq h\frac{v}{\lambda}$, since $E = h\frac{v}{\lambda}$ but $E \neq mv^2$

The assumption would then be to simply leave it as $mc^2 = h\frac{v}{\lambda}$, since both sides are equal to E. However, it now becomes impossible to cancel out the c's from both sides of the equation. The derived equation would then be $\lambda = \frac{hv}{mc^2}$, which is <u>not</u> $\lambda = \frac{h}{mv}$.

Method 2:

For a photon, one equation of finding wavelength is $\lambda = \frac{h}{p}$

here, p, the momentum, is not equal to mv, but rather, the relationship between m and p is:

$$E^2 = m_0^2 c^4 + p^2 c^2$$ where m_0 = rest mass of an object

- This is significant because photons travel near the speed of light.

Since photons have 0 rest mass

(C.) $E^2 = p^2 c^2 \rightarrow E = pc$

Combining this with $E = hf$

(D) $hf = pc$

$$\frac{c}{f} = \frac{h}{p}$$

(E.) $\lambda = \frac{h}{p}$

The assumption made is that for particles with $m_0 > 0$ and $v < c$, p can be substituted with mv to yield $\lambda = \frac{h}{mv}$

However, we were only able to get E because we cancelled the term $m_0^2 c^4$ in C. For particles with $m_0 > 0$, $E = \sqrt{m_0^2 c^4 + p^2 c^2}$,

so instead of D the substitution yields

$$\sqrt{m_0^2 c^4 + p^2 c^2} = hf$$

$$m_0^2 c^4 + p^2 c^2 = h^2 f^2$$

only now can we substitute

$p = m_0 v$

$$m_0^2 c^4 + m_0^2 v^2 c^2 = h^2 f^2$$

(can't isolate λ). $\lambda = \frac{v}{f}$

Where is the error in my thinking?