3.9. Spin voltages

Materials with spin-orbit coupling have unequal number of modes M and N for up and down spins as discussed.

3.9a Consider the relations

\[ + = \frac{M}{M+N} \left( \frac{up+N}{dn} \right) \]  
\[ = \frac{N}{M+N} \left( \frac{up+M}{dn} \right) \]  
\[ + = \frac{M}{M+N} \left( \frac{N}{up-dn} \right) \]  
\[ \text{(A)} \]  
\[ \text{(B)} \]  
\[ \text{(C)} \]

(a) (A) is true, but not (B) and (C)
(b) (B) is true, but not (A) and (C)
(c) (C) is true, but not (A) and (B)
(d) (A), (B) and (C) are all true
(e) None of the above

3.9b The current I can be written as

\[ (a) \quad I = \frac{G_B M}{q} \frac{N}{M+N} \left( \frac{up}{dn} \right) \]  
\[ (b) \quad I = \frac{G_B M}{q} \frac{M+N}{M} \left( \frac{up}{dn} \right) \]  
\[ (c) \quad I = \frac{G_B M}{q} \frac{N}{M+N} \left( + \right) \]  
\[ (d) \quad I = \frac{G_B M}{q} \frac{M+N}{M} \left( + \right) \]  
\[ (e) \quad \text{None of the above} \]