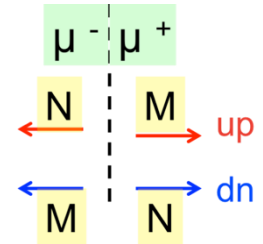


Answers**3.9. Spin voltages**

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

$$m^+ = \frac{M m^{up} + N m^{dn}}{M + N} \quad (\text{A})$$

$$m^- = \frac{N m^{up} + M m^{dn}}{M + N} \quad (\text{B})$$

$$m^+ - m^- = \frac{M - N}{M + N} (m^{up} - m^{dn}) \quad (\text{C})$$

- (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) ((A) and (B) are true but not (C)

3.9b The current I can be written as

$$(a) I = \frac{G_B}{q} \frac{M - N}{M + N} (m^{up} - m^{dn})$$

$$(b) I = \frac{G_B}{q} \frac{M + N}{M - N} (m^{up} - m^{dn})$$

$$(c) I = \frac{G_B}{q} \frac{M - N}{M + N} (m^+ - m^-)$$

$$(d) I = \frac{G_B}{q} \frac{M + N}{M - N} (m^+ - m^-)$$

- (e) None of the above