Quantum Physics 2008/09

Solutions to Tutorial Sheet 10: Bell's Theorem

1. (a) $\frac{1}{4}$

   (b) $\cos^2(\theta_A)\cos^2(\theta_B)$

   (c) $\frac{1}{2}\cos^2(\theta_A - \theta_B)$

   (d) $\frac{1}{4}$

   (e) $\frac{1}{2}\cos^2\frac{1}{2}(\theta_A - \theta_B)$

   The factor of two arises because opposite-polarised photons (x and y) are at 90° while opposite spins $S_z = \pm\frac{1}{2}$ are at 180° to one another.

   Hidden variables methods would give the same result for (a), (b) and (d), but will incorrectly predict for (c) $\frac{1}{4}\cos^2(\theta_A - \theta_B)$ and for (e) $\frac{1}{4}\cos^2\frac{1}{2}(\theta_A - \theta_B)$

   The probability averaged over all θ_A and θ_B is $\frac{1}{4}$ in every case.

2. Obviously there is no unique solution! Alain Aspect wrote a nice summary as a news and views article in Nature.

   Bell's inequality test: more ideal than ever, Nature 398 189 (1999)