Обменное взаимодействие

$$U \sim \mu^2/a^3 \, ,$$

$$a \sim \hbar^2/(me^2),$$

$$\mu \sim e\hbar/(mc) = ea(e^2/\hbar c),$$

$$U \sim (e^2/\hbar c)^2 e^2/a,$$

$$J \sim \exp(-2R/a).$$