First observation at ESR ($^{163}$Dy, $^{187}$Re, $^{206,207}$Tl)

Time-mirrored process of orbital electron-capture decay; predicted by Jean, Daudel and Lecoin in 1947 and observed at the ESR in 1992
\[ A \, Z \, X \rightarrow A \, Z+1 \, Y + e^- + \bar{\nu}_e \]

**Q-value for electric neutral atoms:**
from the mass difference of the atomic masses (mass of the nucleus + mass of the bound electrons)

\[ Q_n = M(Z) - [M(Z + 1) + BE_V + m_{\bar{\nu}}] \]

BE\(_V\) = binding energy of the outer most valence electrons (<25 eV), \(m_{\bar{\nu}}\) = mass of the antineutrinos (<2 eV)

**Q-value of the completely ionized atoms:**

\[ Q_0 = [M(Z) + BE_n(Z)] - [M(Z + 1) + BE_n(Z + 1) + m_{\bar{\nu}}] = Q_n - [BE_n(Z + 1) - BE_n(Z)] \]

BE\(_n\) = sum of the binding energies of all electrons

**Q-value for the \(\beta\)-decay in a bound state of the K-shell:**

\[ Q_K = Q_n - [BE_n(Z + 1) - BE_n(Z)] + BE_K = Q_0 + BE_K \]

BE\(_K\) = binding energy of the K-shell

For \(^{187}\text{Re}, \, ^{241}\text{Pu}\): \(Q_n < [BE_n(Z + 1) - BE_n(Z)]\) is the \(\beta\)-decay into the continuum energetically not possible.
First direct observation of bound-state $\beta$-decay

T. Ohtsubo et al., PRL 95 (2005) 052501
Bound $\beta$-decay: results

- **bound/continuum branching ratio**
- $\rightarrow$ Fermi function $f(Z)$ of the $\beta^-$ decay

- **direct Q-value determination**
bound/continuum branching ratio: 10-20%  

direct Q-value determination