Problems for the Brout-Enlert-Higgs mechanism

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Here are the problems and discussion topics for the Brout-Englert-Higgs (BEH) mechanism. **The results of the tutorial may not be quoted for the homework, but hopefully the calculations will be of help.**

1. Starting from the part of the Standard Model Lagrangian that contains the covariant derivative for the Higgs field defined by Eq. (18.35) in Mandl and Shaw,

$$D^\mu \Phi = [\partial^\mu + ig\tau_j W_j^\mu/2 + ig' Y B^\mu]\Phi, \tag{1}$$

   derive the expressions for the masses of the Z boson and the A boson (photon).

2. Short discussion of the discovery of the Higgs boson. For more information on the discovery, please see the papers by ATLAS[1] and by CMS[2]. There have since been updates on measurements of the different properties of the Higgs boson.

   For more information on the prediction, please see the papers by Robert Brout and Francois Englert[3] and by Peter Higgs[4].

3. Discussion of the Hierarchy problem.

4. Starting from the complete Standard Model Lagrangian, find the Feynman rules for the vertices that originate from these two terms:

$$\frac{vg^2}{4\cos^2\theta_W} Z_\alpha Z^\alpha \sigma, \tag{2}$$

$$g^2 \cos^2\theta_W [W_\alpha W_\beta^\dagger Z^\alpha Z^\beta - W_\beta W^{\beta\dagger} Z_\alpha Z^\beta] \tag{3}$$

[1] `http://www.sciencemag.org/content/338/6114/1576.full.pdf`
[2] `http://www.sciencemag.org/content/338/6114/1569.full.pdf`
[3] `http://link.aps.org/doi/10.1103/PhysRevLett.13.321`
[4] `http://link.aps.org/doi/10.1103/PhysRevLett.13.508`