What is claimed is:

1. A method of detecting a J-coupling comprising:

providing a polarized analyte adjacent to a vapor cell of an atomic magnetometer; and

measuring one or more J-coupling parameters using the atomic magnetometer.

2. The method of claim **1** wherein measuring the one or more J-coupling parameters comprises detecting a magnetic field created by the polarized analyte as the magnetic field evolves under a J-coupling interaction.

3. The method of claim **1** further comprising applying a magnetic pulse to the polarized analyte prior to measuring the one or more J-coupling parameters.

4. The method of claim **1** further comprising polarizing an analyte, thereby forming the polarized analyte.

5. The method of claim **4** wherein polarizing the analyte employs a polarization technique selected from the group consisting of thermalization in a magnetic field, spin-exchange optical pumping, para-hydrogen induced polarization, and dynamic nuclear polarization.

6. The method of claim **4** further comprising transporting the polarized analyte to a detector cell adjacent to the vapor cell of the atomic magnetometer.

7. The method of claim **1** wherein the one or more J-coupling parameters are selected from the group consisting of a heteronuclear scalar coupling parameter, a homonuclear scalar coupling parameter, and a combination thereof.

8. The method of claim **1** further comprising outputting a spectrograph of the one or more J-coupling parameters.

9. The method of claim **1** wherein measuring the one or more J-coupling parameters takes place in a static magnetic field having a magnitude less than about 2.5 nT.

10. The method of claim **1** wherein measuring the one or more J-coupling parameters takes place in a static magnetic field in which a larmor precession frequency for the polarized analyte is less than about 100 mHz.

11. The method of claim **1** wherein measuring the one or more J-coupling parameters takes place in a static low magnetic field having a magnitude less than about 100 μT.

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