σ_{se} is the velocity averaged binary spin exchange cross section; and

K_{xe} is due to spin exchange in the Van der Waals complexes.

The time required to achieve optimal polarization of the ^{129}Xe atoms is influenced both by the ^{87}Rb density and the ^{129}Xe density. Relatively low polarization times can be accomplished by maintaining a relatively high temperature within the vapor cavity **22**. The time integral of the readout signal is proportional to the total angle of mechanical rotation Ω_y of the atomic gyroscope **10** about the y-axis, and is independent of the time dependence of the mechanical rotation Ω_y. Furthermore, the net rotation angle generated by an arbitrary magnetic field transient is equal to zero as long as spin polarizations are rotated by a small angle during the transient. Such feature thus ensures high dynamic range and bias stability as well as high bandwidth.

The atomic gyroscope **10** can be utilized in a number of applications in which reliability, size, power consumption, vibration tolerance, and/or cost are important design considerations. In some applications, for example, the atomic gyroscope **10** can be utilized in Organic Air Vehicle (OAV) control or other navigational systems demanding a high degree of reliability and low power consumption. Other applications such as autonomous ground vehicle navigation, ground vehicle navigation, robotics, underground utility navigation and/or light aircraft control and navigation are also contemplated. In some cases, for example, the atomic gyroscope **10** can be used in personal navigational systems where GPS is not available, such as inside caves or large buildings.

Because the atomic gyroscope **10** uses the magneto-optical properties of spin-polarized vapor gas, the gyroscope **10** is relatively insensitive to B-field and optical field non-uniformities and fluctuations prevalent in nuclear magnetic resonance (NMR) gyroscopes, which measure Larmor precession. Furthermore, the atomic gyroscope has very low cross-axis sensitivity, which contributes to the complexity of many prior atomic gyroscope designs. Moreover, the atomic gyroscope **10** is relatively insensitive to frequency shifts and bias drift common in those atomic gyroscopes that pump and sense along a single axis. In contrast to MEMS vibratory gyroscopes, which utilize mechanical excitation and detection that are more susceptible to vibration, aging, and material degradation, the atomic gyroscope **10** has no moving or vibrating parts, and is thus less susceptible to errors. Also, unlike some ring laser gyroscope designs, the atomic gyroscope **10** is impervious to lock-in at low rotation rates.

Having thus described the several embodiments of the present invention, those of skill in the art will readily appreciate that other embodiments may be made and used which fall within the scope of the claims attached hereto. Numerous advantages of the invention covered by this document have been set forth in the foregoing description. It will be understood that this disclosure is, in many respects, only illustrative. Changes can be made with respect to various elements described herein without exceeding the scope of the invention.

What is claimed is:

1. A chip-scale atomic gyroscope, comprising:

a vapor cell including a vapor cavity adapted to contain a vaporized source of alkali-metal atoms and noble gas atoms;

a pump laser source adapted to produce a first laser beam along an optical pumping axis for optically pumping the alkali-metal atoms within the vapor cavity to an excited state, the first laser beam adapted to induce a nuclear spin polarization in the noble gas atoms; and

a sense laser source adapted to produce a second laser beam along a probe axis transverse to the optical pumping axis for probing the polarization angle of the noble gas atoms within the vapor cavity.

2. The chip-scale atomic gyroscope of claim **1**, further comprising a packaging structure configured to support the vapor cell.

3. The chip-scale atomic gyroscope of claim **2**, further comprising a number of nested shields for magnetically and thermally shielding the packaging structure.

4. The chip-scale atomic gyroscope of claim **1**, wherein the vapor cell further includes one or more storage chambers for containing a supply of alkali-metal atoms and/or noble gas atoms in communication with the vapor cavity.

5. The chip-scale atomic gyroscope of claim **1**, further comprising a means for inducing magnetic fields within the vapor cavity.

6. The chip-scale atomic gyroscope of claim **1**, wherein the vapor cavity further includes one or more buffer gasses.

7. The chip-scale atomic gyroscope of claim **1**, further comprising:

a first light detector in optical communication with the first laser beam transmitted through the vapor cavity;

a first servo mechanism for locking the first laser beam at the carrier wavelength of the alkali-metal atoms, the first servo mechanism adapted to receive feedback signals from the first light detector;

a second light detector in optical communication with the second laser beam transmitted through the vapor cavity; and

a second servo mechanism for locking the second laser beam at a wavelength detuned from the carrier wavelength of the alkali-metal atoms, the second servo mechanism adapted to receive feedback signals from the second light detector.

8. The chip-scale atomic gyroscope of claim **7**, further comprising a set of perpendicular polarization filters in optical communication with the second laser beam and second light detector.

9. The chip-scale atomic gyroscope of claim **1**, wherein the pump laser source comprises a single VCSEL source.

10. The chip-scale atomic gyroscope of claim **1**, further comprising a means for heating the vapor cell.

11. The chip-scale atomic gyroscope of claim **1**, further comprising a passive analog thermal isolation structure in thermal communication with the vapor cell.

12. The chip-scale atomic gyroscope of claim **1**, wherein said chip-scale atomic gyroscope is a microelectromechanical system (MEMS) gyroscope.

13. A chip-scale atomic gyroscope, comprising:

a vapor cell including a vapor cavity adapted to contain a vaporized source of alkali-metal atoms and noble gas atoms;

a pump laser source adapted to produce a first laser beam along an optical pumping axis for optically pumping the alkali-metal atoms within the vapor cavity to an excited state, the first laser beam adapted to induce a nuclear spin polarization in the noble gas atoms;

a first light detector in optical communication with the first laser beam and vapor cavity, the first light detector connected to a first servo mechanism for maintaining the wavelength of the first laser beam at the carrier wavelength of the alkali-metal atoms;

a means for inducing a magnetic field within the vapor cavity;

a sense laser source adapted to produce a second laser beam along a probe axis transverse to the optical