A. M. Shalagin. *Light-induced drift and its manifestations, particularly in astrophysics.* The light-induced drift (LID)[1] phenomenon is one of the strongest effects of light interacting with translational motion of gas particles. The essence of LID can be described as follows. Let us suppose that radiation passes through a two-component gaseous medium and resonantly excites one of the components. For concreteness we will take the spectral radiation line to be narrower than the Doppler-broadened absorption line. In this case the Doppler effect causes the radiation to selectively transfer the particles from one (ground) quantum state to another (excited) state as a function of particle velocity. Moreover, we will assume that the particles change their internal state without altering their velocity, i.e. light pressure is neglected. Then, given some frequency detuning of the central radiation frequency from precise resonance (as long as the radiation still falls within the absorption line) the velocity-selective interaction will produce crossed beams of particles in the ground and excited quantum states. Since particle velocity is unaffected by optical transitions the radiation induces particle beams that are equal in intensity but travel in opposite directions. These beams are subject to resistance (friction) from the buffering component of the gaseous mixture. Generally the resistance experienced by these two beams is different because the ground and excited particle states have different transport characteristics. Consequently, a net force results on the absorbing medium, which leads to directional motion (drift) of the aborbing component as a whole with respect to the buffering component. The drift direction is either parallel or antiparallel to the radiation propagation vector, depending on the sign of the frequency detuning from the central absorption frequency and on the difference in transport characteristics.

We emphasize that the LID effect leads to the spatial separation of the two gas components but not to motion of the gaseous mixture as a whole, i.e., the total pressure remains unchanged. This follows from momentum conservation since the radiation does not transfer momentum to the medium. The LID effect is thus a distinct type of radiation interaction with the translational motion of gas particles. In a number of cases, such as electronic transitions in atoms, radiant energy may not dissipate into heat (the excited state relaxes by radiation only). In this scenario the energy and momentum of translational motion of gas particles remain integrals of motion, and the role of radiation in LID is akin to Maxwell's demon.

Currently, the theory of LID is fairly well developed. The simplest theoretical pictures are discussed in Ref. 2. In addition, a large number of experiments intended to observe and investigate LID have been carried out in atomic[3,4] and molecular[4,5] systems. It has been demonstrated experimentally that in a laser field the LID effect can cause atoms to drift with velocities of the order of several tens of m/s and accumulate in layers thinner than 1 mm.[4] In the case of molecules the separation of components occurs on the ~ 1 m scale.[5]

The experiments have shown that LID effects are some five orders of magnitude stronger than light pressure effects in identical conditions.

The cycle of experimental studies has demonstrated that LID can furnish a unique and reliable means of measuring the transport characteristics of short-lived atomic and molecular states, filling a previously existing need.

The experiments have convincingly demonstrated the possibility of separating atomic[6] and molecular[5] isotopes. Estimates indicate that isotope separation by LID appears quite promising.

The LID effect has also been utilized to separate the nuclear spin modifications of heavy molecules.[7] In this regard LID appears to be the most promising separation technique, making it possible to study the properties of spin modifications of molecules in detail.

Light-induced drift can be employed to improve the sensitivity of laser-based methods of detecting atomic microimpurities.[8] The effect can serve as a "trap" which collects and stores the atoms one is trying to detect. Sodium vapor has been concentrated by a factor of $\sim 10^3$, and this figure can be improved by several orders of magnitude.

The utilization of LID as a selective optical pump can either purify a medium of microimpurities or, conversely, deliver the impurities to a required site. Thus the LID-based method of controlling gaseous impurities should find technological application wherever special purity or measured delivery of a component to a particular site are required.

The strong effects caused by LID, as well as its dominance over light pressure in some circumstances, lead one to suppose that LID may play a major role in some astrophysical phenomena. It has been suggested in Ref. 9 that LID may explain the chemical pecularity of stars: the authors have demonstrated that in the atmosphere of these stars LID is several orders of magnitude more effective than light pressure in separating chemical elements. The LID effect has been invoked to explain the isotopic anomaly of helium and to predict similar anomalies in other elements.

It appears likely that the chemical inhomogeneities over the surface of some pecular stars, as well as their magnetic fields, are due to the combined effects of LID and convection. A possibly significant role for LID has been proposed for cosmic masers, and also for the separation of chemical elements and isotopes in the protoplanetary cloud of the Solar system.

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