LASER COOLING AND STOCHASTICS

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In the statistical analysis of cooling and trapping of atoms by a combination of laser and magnetic field technology, Aspect, Bardou, Bouchaud and Cohen-Tannoudji (1994) showed that Lévy flights is the key tool. A review of their analysis, from the point of view of renewal theory and occupation times for stochastic processes, is given here and some further analysis provided. Brief discussions of two related types of models are also given.

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1 Introduction

Cooling and trapping of atoms, by a combination of laser and magnetic field technology, is a subject area of great current interest in physics. By directing a number of laser beams towards a chosen point in space and setting up a suitable magnetic field around the point it is possible to hold a cloud of atoms largely concentrated in a very small region around the point, as indicated in Figure 1. The basis of the techniques is the fact that light acts mechanically on material objects, such as atoms, meaning that it can change their positions and velocities. Each single atom follows a random trajectory, but is staying most of the time near the centre of the trapping region; it moves very little and is therefore 'cold'.

Stochastic considerations have led to a substantially better understanding, and subsequently to a dramatic improvement in efficiency, of the cooling; see Bardou et al. (1994), Bardou (1995) and Reichel et al. (1995).

Of particular interest are the questions:

(i) how much of the total time of the experiment does the momentum (vector) of the atom belong to a small neighbourhood of the origin.

(ii) what is the distribution of the momentum given that it belongs to such a neighbourhood.

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