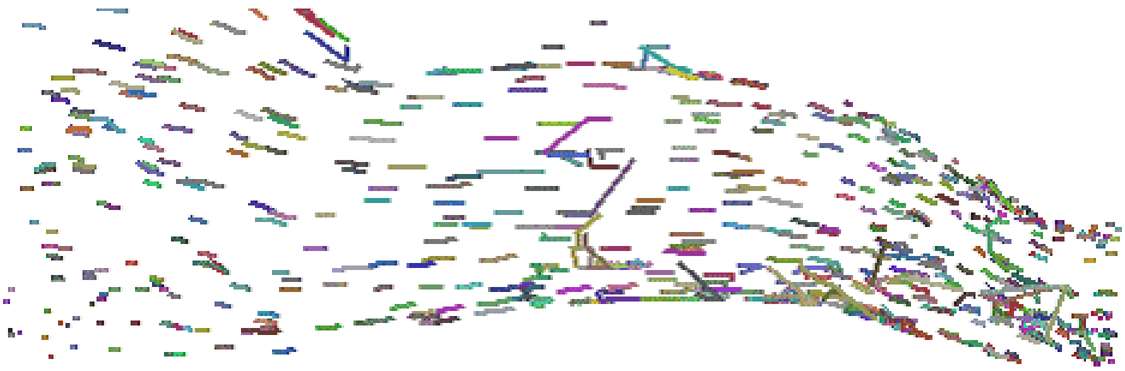
Particle Tracking Using an Evolutionary Approach

The investigation of the dynamics of the plasma crystal requires an efficient tracking of the particles. In our approach the matching of the particles in subsequent images may be considered as optimising some smoothness condition. Biologically motivated techniques like genetic algorithms or evolutionary strategies are an interesting alternative for solving such complex problems. In this study, the suitability of these techniques for particle tracking is examined.

The analysis of many features of the plasma crystal dynamics requires the knowledge of the particle trajectories. Their determination is difficult in the presence of hundreds of particles which may flow in and out of the focus of the camera and particle trajectories may cross in the visible plane. In the turbulent or chaotic regime this task becomes even more difficult. Such problems can be approached by applying a heuristic method that optimises several properties.



Displayed are the trajectories of particles as they were determined by an evolutionary approach. Starting point of the analysis are the particle positions in five consecutive time steps. The algorithm joins this unordered set of particles to trajectories, which were colour marked for better distinction here. The errors in the result can be corrected by suitable post-processing.

Genetic algorithms or evolutionary strategies mimic biological phenomena like mutation, genetic recombination and selection in order to solve multi-objective optimisation problems. For that purpose a pool of “individuals” is generated, of which each represents a possible solution. In each iteration step, descendents are created based on this parent generation by recombination and mutation. The quality of a solution by an individual is evaluated with a fitness function. A selection mechanism guarantees that only the “fittest individuals” (i.e. the best solutions of the problem) attain the next generation. These methods, which are motivated by nature, are an interesting alternative to other optimisation procedures as for example simulated annealing.

Applied to particle tracking, an individual consists of a set of paths. Recombination can be implemented e.g. by mixing two different paths and mutation is imitated by randomly changing an element of a path. The fitness of each individual is assessed with respect to the properties of the single trajectories: the length of the path is evaluated as well as the constancy in direction and speed.

In numeric experiments good results could be obtained. However the multiplicity of free parameters appears problematic because of the high computation time needed. In order to reduce the dimensionality of the problem, a more compact description of the individuals is necessary. The computational effort can substantially be reduced by parallelisation of the algorithm. However, this technique seems to be a promising approach for analysing the plasma crystal experiments.

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