# Report on the results of the STSM

## i. Purpose of the STSM

The collaboration of Dr. Jiri Stepan (AIAS) with Prof. Javier Trujillo Bueno (IAC) started during the post-doctoral stay of Jiri Stepan at the IAC. One of the main results of this collaboration was the development of the general radiative transfer code PORTA (Stepan & Trujillo Bueno 2012; 2013), capable of solving three-dimensional, non-LTE, multilevel radiative transfer problems including the spectral line polarization governed by anisotropic optical pumping, atomic polarization, collisions, and the Hanle and Zeeman effects. We are now applying PORTA to investigate several interesting radiative transfer problems in 3D atmospheric models resulting from state-of-the-art magnetohydrodynamical (MHD) simulations (see a first example in Stepan, Trujillo Bueno, Carlsson and Leenaarts 2012; ApJ Letters). The purpose of this STSM was to prepare the PORTA code for running it in massively parallel supercomputers (e.g., by implementing new parallel algorithms for three-dimensional radiative transfer), to test the performance of this implementation, and to prepare a detailed paper. Parallelization of our 3D transfer code is an essential development, because it increases the speed of the calculations by several orders of magnitude, making feasible much more realistic radiative transfer simulations.

## ii. Description of the work and the main results obtained during the STSM

We have tested PORTA using a five-level atomic model including scattering polarization, optical pumping and collisional depolarization. The two particular cases we have considered are the following:

1) We have finished the implementation of a new algorithm, called the Snake Algorithm (SA), suitable for the parallel solution of the non-LTE radiative transfer problem. The algorithm is suitable for radiative transfer simulations with fine angular quadratures and a large number of radiation frequencies (i.e., as is the case for resonance line polarization). We have incorporated the SA into the code PORTA using the MPI library and we have combined it with the non-linear multigrid iterative scheme on which PORTA is based.

2) We have tested the new algorithms using a 3D model atmosphere obtained from horizontal perturbations in a semi-empirical model of the solar atmosphere. The numerical tests have been performed using the Ondrejov Cluster for Astrophysical Simulations (AIAS). Unfortunately, the IAC cluster was down during November 2012, but in 2013 we plan to run PORTA also in La Palma cluster and in the Barcelona Supercomputing Center. The tests we have carried out up to now confirm that the scaling of the convergence speed is practically linear with the number of computing cores, providing an optimal scaling behavior for our forthcoming massively parallel simulations.

3) We have prepared a manuscript of a detailed paper, to be submitted in January 2013 to an international peer reviewed journal (Stepan & Trujillo Bueno, 2013). This paper describes in detail the design, the new algorithms, and the implementation details of PORTA.

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iii. **Future collaboration with host institution**

The collaboration carried out during this STSM has led to a considerable improvement of the capabilities of our radiative transfer code. This work was an essential first step towards making feasible spectropolarimetric investigations of the magnetism of the outer solar atmosphere. We are planning to apply our novel radiative transfer tools for the investigation of multiple chromospheric and transition-region spectral lines sensitive to scattering polarization, the Hanle and Zeeman effects. These research problems will be addressed in detail in our ongoing and near-future collaborations.

iv. **Foreseen publications resulting from the STSM**

The results of the STSM collaboration will be published in a refereed journal (Stepan & Trujillo Bueno, 2013) and will be presented also in international conferences. Some extra publications of related research work resulting from other collaborations, with Dr. L. Belluzzi (IAC) and Prof. J. Trujillo Bueno (IAC), are also planned (e.g., the computation of coherent scattering polarization signals in the wings of strong resonance lines).

v. **Confirmation by the host institution of the successful execution of the STSM**

The host institution (Instituto de Astrofisica de Canarias), represented by the undersigned Prof. Javier Trujillo Bueno, confirms that the STSM has been very successful and is leading to new scientific advances.

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