# PhD First Year Report

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## Summary of scientific activity

The aim of my PhD project is to develop an instrument to measure the optical properties of atmospheric particulate matter (PM), with special attention to carbonaceous compounds. Particulate matter identifies a broad range of compounds that come in a large variety of shape, size and composition. Many of these compounds, for example carbonaceous aggregates or various types of mineral dusts, are also optically active. This feature has important consequences on the climate, namely the modification of the heat retentive qualities of the atmosphere (greenhouse effect). In order to investigate this effect, it is fundamental to measure the absorbance of the particulate matter with as high spectral resolution as possible. During the first year of my PhD, I have worked both on the hardware and on the software sides of my project. In particular:

- **Hardware:**
  I have developed the first prototype of the instrument. In its current setup, BLAnCA (Broadband Light Analyzer of Carbonaceous Aerosol) is made up of two main components: a light source and a spectrometer. The design of the instrument resembles closely the Multi-Wavelength Absorbance Analyzer (MWAA), designed and built by the Environmental Physics Group where I carry out my project. While the MWAA utilizes five laser diodes as light sources, BLAnCA uses a broad spectrum white light source, greatly extending the spectral resolution of the resulting absorbance measurement. The light emitted from the source, with an approximately black-body spectrum peaked at 750 nm, is absorbed and scattered by the particulate matter gathered on a filter support. In this first prototype, the light is channeled to the spectrometer through three fiber-optic cables whose inputs are placed around the sample at angles of 0°, 125° and 195° with respect to the incident light direction. These angles have been chosen because they allow a better reconstruction of the radial profile of the backscattered light. With the spectrometer is then possible to measure the alterations in the transmitted and scattered light spectrum. After assembling the BLAnCA instrument on an optical bench, I carried out validation measurements to compare it to the already established MWAA. I measured the absorbance of the synthetic PM gathered on a batch of 45 quartz fiber filters with both instruments. BLAnCA measurements were restricted to the five wavelengths of the MWAA to make a one-to-one comparison possible. These tests showed excellent performance with a very high correlation of the values of absorbance obtained with the two instruments. The second version of the instrument will include the possibility to perform a polar light measurement, to reconstruct very precisely the transmitted and scattered light profile. The mechanical mount and the rotation stage needed for this upgrade are currently under construction at the INFN workshop.
- **Software:** For the purposes of my PhD project, software has to provide two functionalities. First, the analysis of the raw spectra captured at each angle in order to obtain the spectral dependence of the absorbance of the particulate matter. Second, an implementation of a mathematical model which allows to distinguish the sources of the particulate matter, and its mass composition, starting from the spectral dependence of its absorbance. I devoted a large portion of my first PhD year to the first of these two tasks by writing from scratch an extensive Python package, whose first version is now finalized. In the process, I also completely renovated and improved the analysis software for the MWAA, which was the logical first step since the instrument works in a similar fashion to BLAnCA but is less complex.

## Attended courses

- Observational astronomy (exam passed);
- Electronics and data acquisition;
- Quantum optics;

## Summer schools

- Aerosol Summer School, University of Vienna, 10-16 July 2022

## Conferences

- Poster presentation at the $10^{th}$ national conference of the Italian Aerosol Society (PM2022), Bologna, 18-20 May 2022;
- Poster presentation at the $11^{th}$ International Aerosol Conference (IAC2022), Athens, 4-9 September 2022;
- Talk at the $108^{th}$ national conference of the Italian Physical Society (SIF), 12-16 September 2022