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Abel inversion method for cometary atmospheres.

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Remote observation of cometary atmospheres produces a measurement of the cometary emissions integrated along the line of sight joining the observing instrument and the gas of the coma. This integration is the so-called Abel transform of the local emission rate. We develop a method specifically adapted to the inversion of the Abel transform of cometary emissions, that retrieves the radial profile of the emission rate of any unabsorbed emission, under the hypothesis of spherical symmetry of the coma. The method uses weighted least squares fitting and analytical results. A Tikhonov regularization technique is applied to reduce the possible effects of noise and ill-conditioning, and standard error propagation techniques are implemented.

Several theoretical tests of the inversion techniques are carried out to show its validity and robustness, and show that the method is only weakly dependent on any constant offset added to the data, which reduces the dependence of the retrieved emission rate on the background subtraction.

We apply the method to observations of three different comets observed using the TRAPPIST instrument: 103P/ Hartley 2, F6/ Lemmon and A1/ Siding spring. We show that the method retrieves realistic emission rates, and that characteristic lengths and production rates can be derived from the emission rate for both CN and C2 molecules. We show that the emission rate derived from the observed flux of CN emission at 387 nm and from the C2 emission at 514.1 nm of comet Siding Spring both present an easily-identifiable shoulder that corresponds to the separation between pre- and post-outburst gas. As a general result, we show that diagnosing properties and features of the coma using the emission rate is easier than directly using the observed flux. We also determine the parameters of a Haser model fitting the inverted data and fitting the line-of-sight integrated observation, for which we provide the exact analytical expression of the line-of-sight integration of the Haser model.