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Unidentified emission lines in comets: recognition and implementation in the *comet lines tool* at the IDIS Small Bodies and Dust Node

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Abstract

Unidentified lines of five comets from four cometary emission lines catalogs (23P/Brorsen-Metcalf [1], 109P/Swift-Tuttle [1], 122P/De Vico [2], 153P/Ikeya-Zhang [3] and C/1995 O1 Hale-Bopp [5]) are the subject of this work. These lines are all included in the database of the *comet lines tool* at the IDIS Small Bodies and Dust Node (SBDN). An objective criterium to recognize which unidentified lines could be considered to be spectral marks of the same transition in different comets is established.

1. Introduction

The SBDN is one of the thematic nodes of the EuroplaNet IDIS network, a service providing access to both satellite and ground observatories data, internal and external tools and facilities. A tool which has been internally developed by the SBDN team is the *comet lines tool* which allows the user to operate a simple query returning wavelengths, species and transitions of the whole set of 32232 emission lines collected within the four catalogs [1], [5], [2] and [3] and joined toghether in the *comet lines tool* database.

According to Levison classification [4], the five objects belong to the family of nearly isotropic comets and all of them are of the returning type. The comets have been observed by ground-based telescopes on which Echelle spectrographs with very different resolving power were mounted to obtain the spectra.

Emission lines tell us about the composition of the comets but, within these catalogs, many lines have not been identified. The aim of the work is to find those unidentified lines which are likely to represent the same transition in different comets.

2. Procedure and analysis

Before starting any analysis, a Doppler shift adjustment of the wavelengths of unidentified lines of catalogs [1] and [5] is needed. The three components of the velocities of the Earth and the comets are calculated with the NASA HORIZONS web interface. Both the observer and the source are considered to be in motion: approximations would lead to large errors, even of the order of 1 Å. We use equation 1 to calculate the rest frame wavelength (λ_0) starting from the catalog wavelength (λ).

$$\lambda_0 = \lambda \frac{c - v_{Earth}}{c + v_{comet}} \tag{1}$$

where v_{Earth} and v_{comet} are the projections of the velocities of the two bodies on their connecting line. They are negative if the body is moving towards the other body and positive otherwise.

From Table 1 we see that the database does not contain any data on the spectra intensities. To say the thruth, two of the four catalogs ([1] and [3]) do report the relative intensity of the lines at their peak, but not of the whole spectra, so we cannot compare intensities and equivalent widths to recognize the lines: we only have the peaks' wavelength at our disposal.

We then establish another method: looking at Table 1 we spot the C_2 Swan 0-1 R2(20) transition line in three comets. This is a triplet within a 0.004 Å range. Our idea is to measure these ranges (which, from here on in, we will call δ) for a sample of identified lines (532 pairs, 237 triplets, 202 quadruplets and 29 quintuplets, for a total of 1000 transitions and 2728 lines) and finally calculate the mean value of the δ distribution. This value is set to be the threshold to

λ[Å]	Species	trans$_e$	trans$_v$	trans$_r$	Comet	Catalog
5586.150	Unid				De Vico	[2]
5586.160	Unid				Ike-Zha	[3]
5586.305	Unid				Ike-Zha	[3]
5586.320	Unid				De Vico	[2]
5587.520	C_2	Swan	0-1	R1(21)	Ike-Zha	[3]
5587.530	C_2		(0,1)	R1(21)	Swi-Tut	[1]
5587.533	C_2	Swan	0-1	R1(21)	De Vico	[2]
5587.680	C_2		(0,1)	R2(20)	Swi-Tut	[1]
5587.684	C_2	Swan	0-1	R2(20)	Ike-Zha	[3]
5587.684	C_2	Swan	0-1	R2(20)	De Vico	[2]

Table 1: A sample of rows of the *comet lines tool* database. Wavelength, species, electronic, vibrational and rotational transition and the comet where the line has been detected are shown. It has to be noticed that catalogue [1] (as catalogue [5] whose no item is visible here) does not report the electronic transition and has a slightly different transition nomenclature format.

determine wheter two or more unidentified lines found in different comets can be considered to correspond to the same transition.

3. Results

We calculated the mean value of the δ distribution to be $\delta_{mean} = 0.019$ Å; the cumulative distribution at δ_{mean} is 0.74 (740 on 1000 elements). Finally, using this threshold, we spotted, amongst the 6550 unidentified lines of the whole database, 128 couples and 13 triplets of lines that are likely to have been produced by the same transition in different comets.

The mean value and the median of the δ distribution of unidentified lines are, respectively, $\delta_{mean(Unid)} = 0.007$ Å and $\delta_{median(Unid)} = 0.003$ Å.

The identification of species and transitions of unidentified lines goes beyond the aim of this work but this result can be a clue and a starting point for future works with that goal.

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