AMAZED: Algorithm for Massive Automated Z Evaluation and Determination

A. Schmitt*, S. Arnouts*, R. Borges*, P.Y. Chabaud*, F. Fauchier*, S. Jamal*, V. Le Brun*, O. Le Fèvre*, C. Surace*, D. Vibert*, C. Vidal*
*Laboratoire d'Astrophysique de Marseille

Abstract

- As of today, at z>1, the best redshift estimation is done by humans. Next generation galaxy surveys with millions of galaxies require a fully automated process with no human intervention. **The goal of AMAZED is to automatically measure the redshift of any galaxy and an associated redshift reliability**. This requires new generation algorithms.
- AMAZED is an automatic redshift estimation software package developed in the framework of both **EUCLID and PFS large-scale spectroscopic surveys** involving the LAM. The AMAZED project aims at providing a fully automated and versatile (instrument type, resolution, ...) redshift estimation tool.
- AMAZED focuses on future all-sky surveys in a low-noise regime like the **NISP slitless spectrograph surveys** on the ESA-Euclid mission (applicable to NASA-WFIRST), as well as future **deep pointed surveys with massively multiplexed spectrographs** like the Subaru Prime Focus Spectrograph.
- This poster is focused on some algorithmic concepts and results obtained with simulated data and real data.

Method Overview

The AMAZED framework API is based on the use of **Operators** and **Methods**.
Operators are the algorithmic bricks (template-fitting, linemodel, ...). These bricks, as individual algorithms, are combined in a complete and more complex program.
Each operator is defined with specific input, depending on the nature of the algorithms used in the operator.

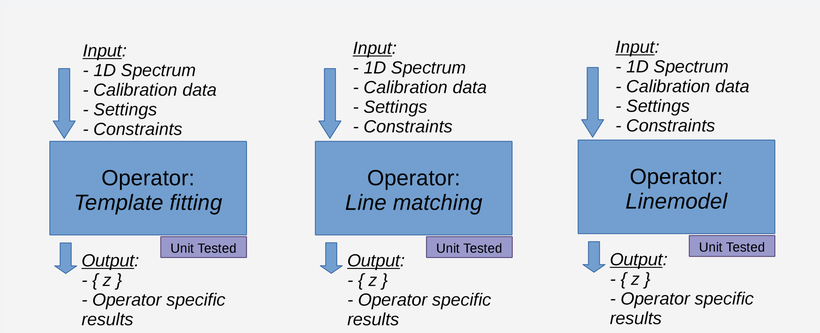

Figure 1.1: ***AMAZED operator concept****: an algorithmic brick*

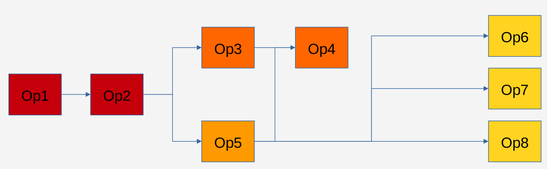

Figure 1.2: ***AMAZED method concept****: combining operators together*

This modular structure is built around a single C++ library for redshift estimation that is subsequently included in two distinct applications: one to reduce data from PFS, another to reduce data from Euclid.

Template fitting Operator

- Amazed's template fitting operator inherits from the *cross-correlation* method introduced by Tonry Davis [1], and by Garilli et al [2].
- It can be applied on different spectrum components such as the raw observed spectrum, the continuum component or the continuum-subtracted component, providing complementary information. The example of a spectrum from the VUDS ECDFS survey [3][4] is given in the figure 2.2, along with the Least-Square function for each component as a function of the redshift on Figure 2.1.
- The templates used for the results presented here after have been extended in wavelength to reach a homogeneous redshift coverage.

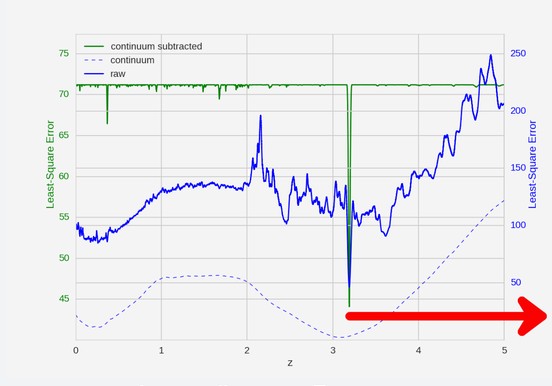

Figure 2.1: ***Least-Square Error curves*** *for the template fitting with continuum (dashed blue), raw (blue) or continuum subtracted (green) component, VUDS ECDFS spectrum 530004745 and template COMBINE-ave-Lya-emstr-AND-StarBurst1*

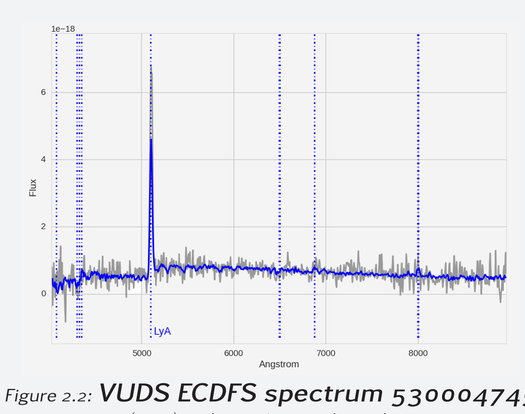

Figure 2.2: ***VUDS ECDFS spectrum 530004745*** *(gray) and superimposed template COMBINE-ave-Lya-emstr-AND-StarBurst1 (blue) at* ***z=3.173***

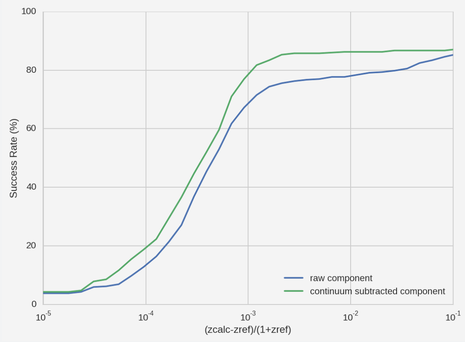

Figure 2.3: ***Redshift estimation cumulative success rate****, for the template fitting operator with varying spectrum component (raw or continuum subtracted), for the VUDS ECDFS (Flags 3+4) dataset [3][4] (421 spectra)*

[1]*Tonry, J., Davis*, M. 1979, AJ, 84, 1511 [2]*EZ*, Garilli et al., 2010.
[3]*Le Fèvre et al.*, 2015, AA 576, 79. [4]*Tasca et al.* arXiv:1602.01842 [astro-ph.GA].

Amazed Team

V. Le Brun (Scientific responsible), O. Le Fèvre (Euclid Science responsible), S. Arnouts, C. Surace (Euclid OU-SPE responsible), R. Borges, P.Y. Chabaud, F. Fauchier, S. Jamal, A. Schmitt, D. Vibert.

Continuum Subtraction operator

The continuum removal operation is based on the decomposition of the spectrum (S) into its continuum (C) component and its continuum subtracted (S_{SC})*component, suchas* : $S = C + S_{CS}$
Several continuum estimation methods are under investigation, such as the *Multiscale Median Transform* (EZ, Garilli et al., 2010) and the *Darth Fader algorithm* (Machado et al., 2013).

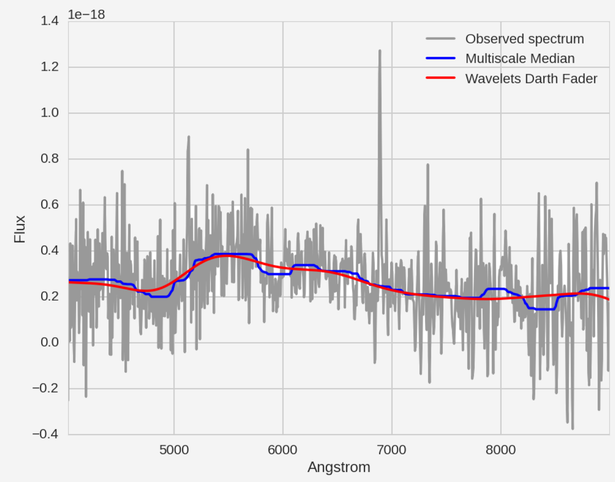

Figure 3: ***Continuum estimation methods comparison****: Spectrum VUDS ECDFS 530002417. Median filter with window size parameter set to 150A (blue), and Darth Fader wavelets with scale parameter set to 6 (red)*

Linemodel Operator

The linemodel operator consists in fitting simultaneously the parameters of a set of lines from a rest-frame catalog by looping on all redshifts. It is based on the following model:

$$M(\lambda)_z = C(\lambda) + L(\lambda)_z \quad (1)$$

with C, the previously blindly estimated continuum from the observed spectrum, and L, the lines such as:

$$L(\lambda)_z = \sum_i a_{i,z} e^{\frac{-(\lambda-\mu_{i,z})^2}{2\sigma^2}} \quad (2)$$

- By fitting simultaneouly all the lines in a catalog, the linemodel improves the redshift estimation at lower signal-to-noise ratios in comparison to a single line detection algorithm.

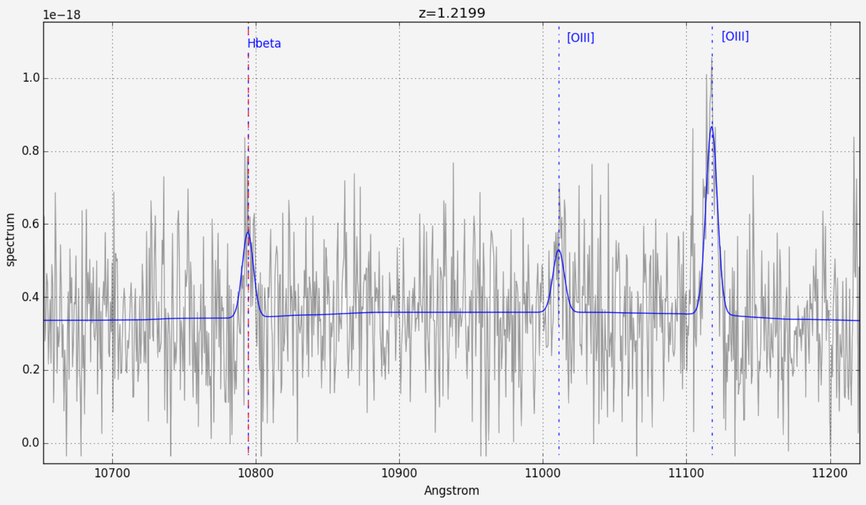

Figure 4.1: ***Linemodel fit example*** *on a low SNR simulated spectrum*

- The first results obtained on 2160 high resolution simulation spectra (synthesized by the Amazed team as a performance testing dataset) with varying Magnitude [21 to 26], Star Formation Rate (SFR) [0.1 to 100] and redshifts [0 to 7] show good overall success rates except for very faint and low SFR objects.

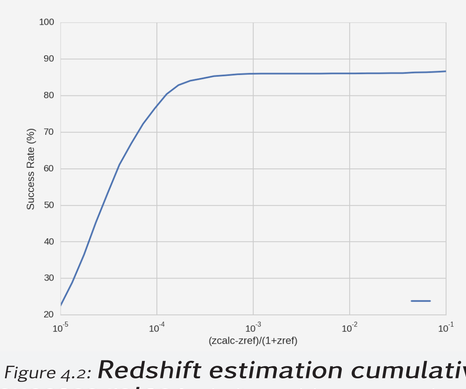

Figure 4.2: ***Redshift estimation cumulative success rates*** *for the linemodel operator on the 2160 simulation spectra. 86% of the redshifts are successfully recovered with a relative error <0.001.*

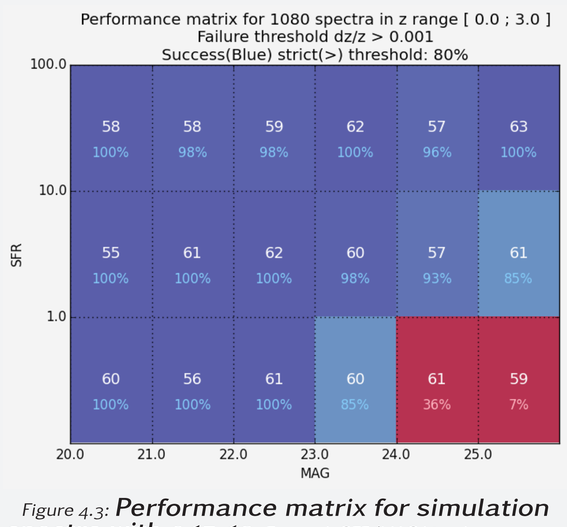

Figure 4.3: ***Performance matrix for simulation spectra with 0<z <3****. For each SFR/MAG bin, the spectrum count (top white number) and the success rate (in %) are given. A given redshift estimation is considered successful if it's relative error is lower than 0.001. It can be observed that only the bins jointly caracterized by low SFR (<1.0) and faint magnitude (>24) have success rates below 80%*

Next steps

We are developing the operator to quantify the redshift reliability, and will conduct extensive tests on simulated and real spectra towards a 100% success rate

Address and Contacts

- CESAM (Centre de Données Astrophysiques de Marseille) software tools address is https://www.lam.fr/cesam/les-outils.
- EUCLID (http://www.euclid-ec.org/)
- SUMIRE-PFS (http://sumire.ipmu.jp/en/)