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Conditional Variational Autoencoders for the analysis of the Gaia spectrophotometric data of pre-main sequence stars

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The characterization of the pre-main-sequence (PMS) stars from the Gaia spectrophotometric data is one of the new objectives for the fourth Gaia Data Release (DR4). The mass accretion taking place through the protostellar disc in PMS stars induces an additional component of continuum radiation excess with respect to what is observed in main-sequence stars. Such a continuum excess is detectable in the wavelength range observed by the low-resolution Gaia BP/RP spectrophotometer (300-1100 nm). The Extended Stellar Parametrizer - Cool Stars (ESP-CS) module of the Gaia astrophysical parameters inference system aims at analyzing the BP/RP spectra in order to determine the stellar and accretion parameters for each source: effective temperature, surface gravity, metallicity, mass, extinction, mass accretion rate and filling factor.

The ESP-CS inference method presented in this talk is based on the Conditional Variational Autoencoders (CVAE). We trained the CVAE on a pre-computed grid of BP/RP model spectra parametrized by the stellar and accretion parameters. Our CVAE are not then data-driven, as they are conditioned on model spectra based on the magnetospheric accretion model. CVAE allow us to embed the information on the stellar and accretion parameters into the encoder and decoder networks. In this way, the latent space represents both the BP/RP model spectra and their associated parameters. Convolutional layers are employed for both the encoder and the decoder architectures. The trained CVAE are employed to infer the stellar and accretion parameters of the PMS stars by passing the observed BP/RP spectra to the decoder network. The variational nature of the method allows us to feed different realizations of the latent space into the decoder as samples from statistical distribution, thus providing posterior samples of the inferred parameters. Our Java implementation allows us to analyze one BP/RP spectrum in about 3 seconds on an intel core i7 laptop.

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