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de Strasbourg



FEMMES & SCIENCES
association



Présentation de parcours

Victoria Callet-Feltz

Enseignante en mathématiques

Docteure en mathématiques

Quelles études ?

- **Collège** de Villé (2000 habitants)
- **Lycée** général à Sélestat (20 000 habitants)
- **Baccalauréat** Scientifique (Maths + Physique + SVT)
- **Licence** de Mathématiques (3 ans)
- **Master** d'Enseignement/Recherche en Mathématiques (2 ans)
- **Concours** d'enseignement (Agrégation)
- **Thèse** de Mathématiques (3 ans)



Quel travail ?

Enseignante – Chercheuse
en mathématiques

Enseigner les maths



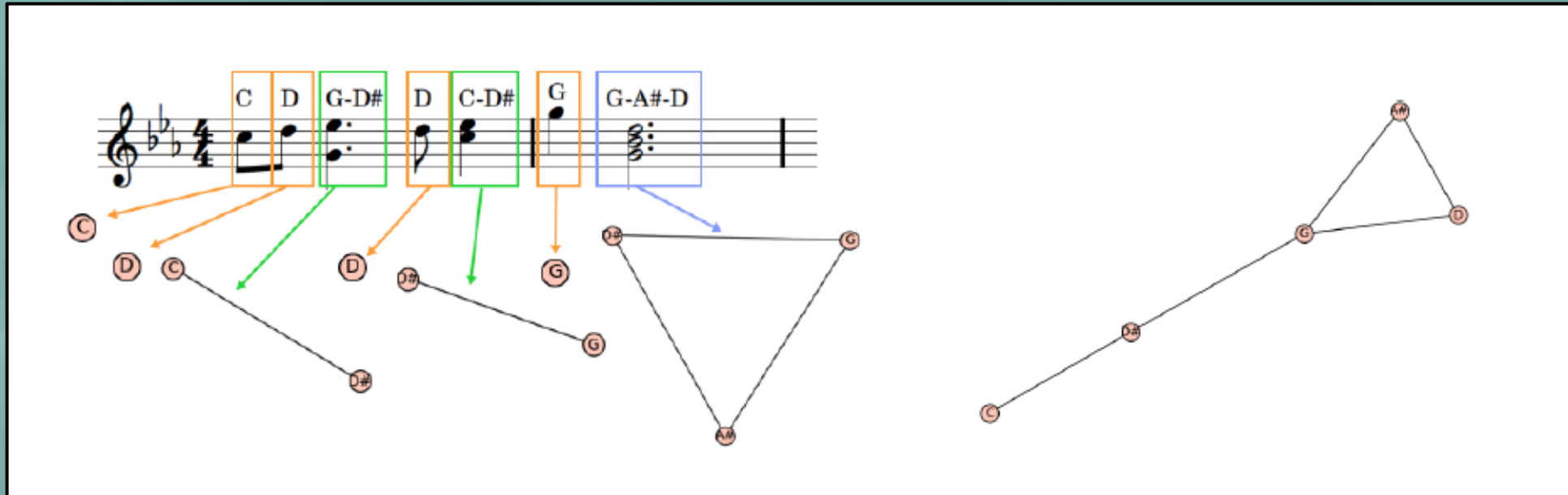
Ecole d'ingénieurs à Strasbourg (INSA)

Faire de la recherche en maths



Laboratoire de maths à Strasbourg (IRMA)

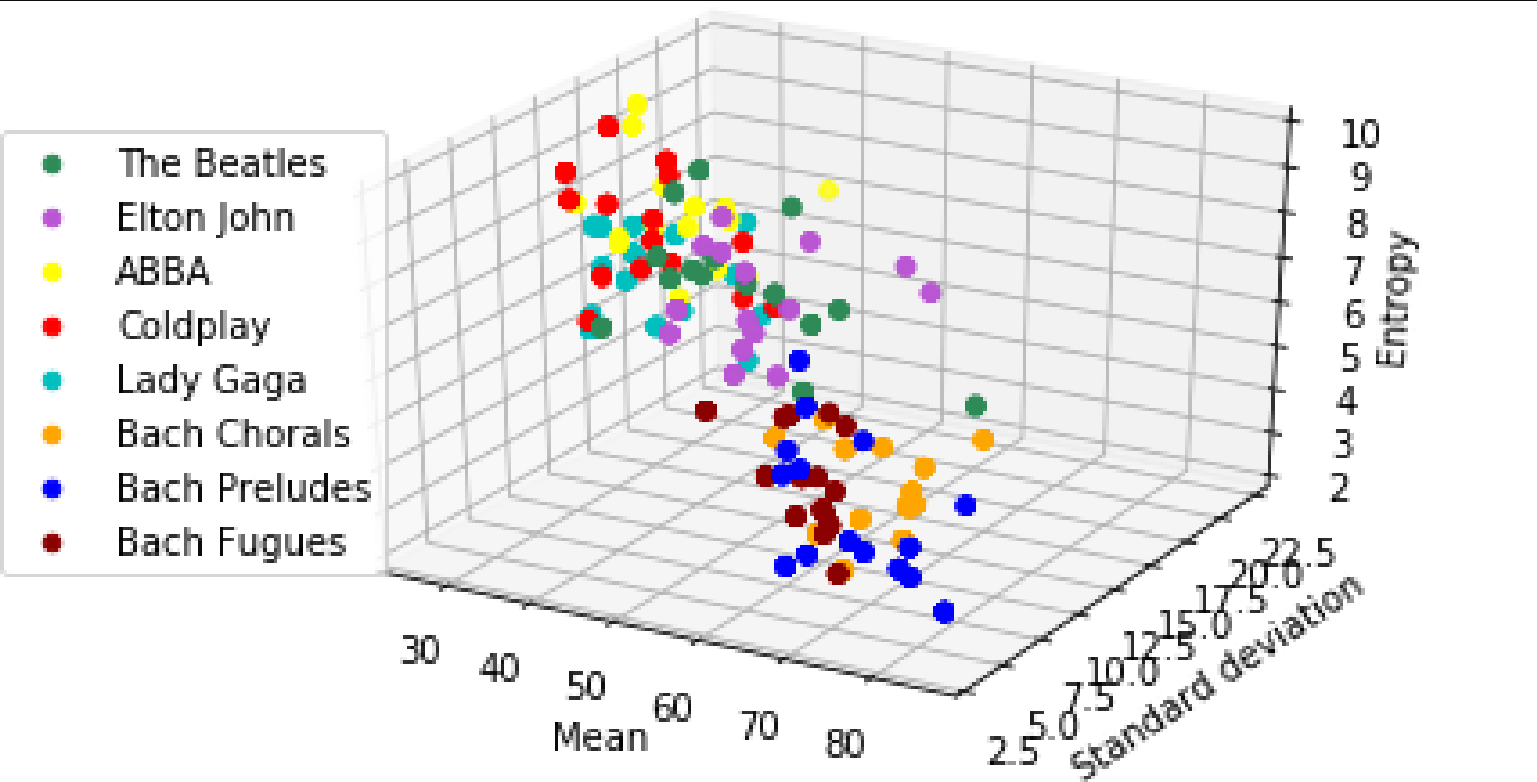
Mon travail de recherche : « Modélisation topologique des structures et processus musicaux »



Des mathématiques appliquées à la musique :
la géométrie des partitions

Classification automatique du style musical

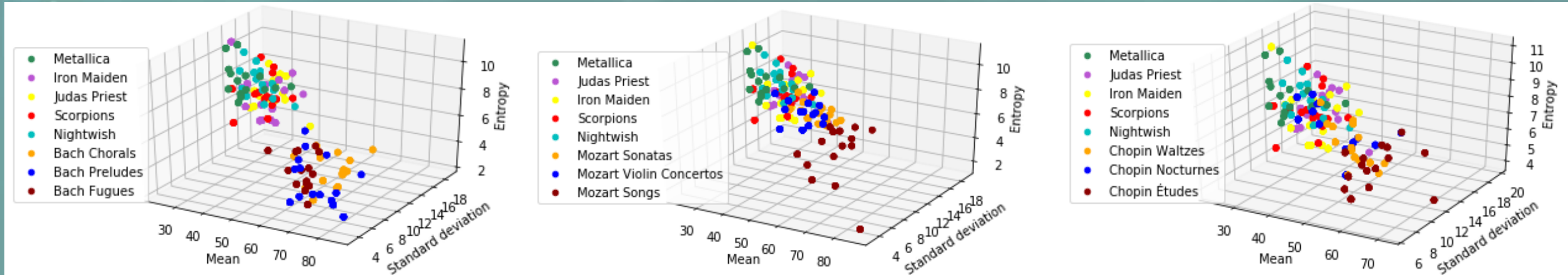
De la Pop VS Jean-Sébastien Bach



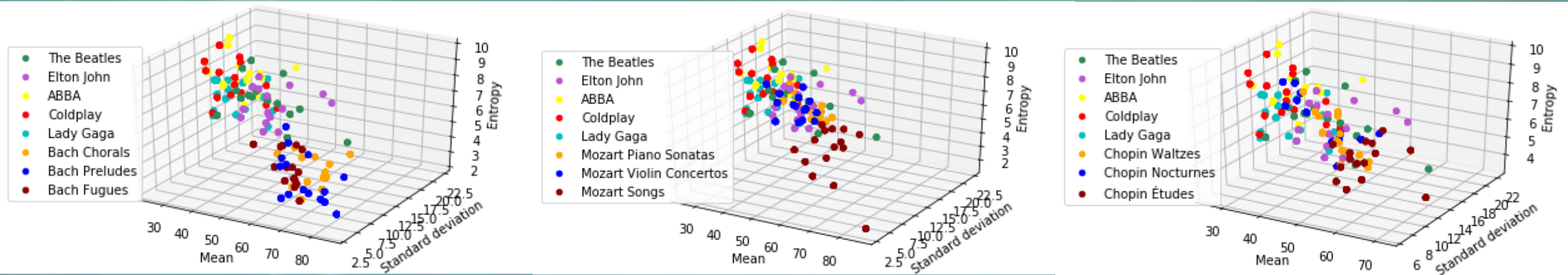
- Création d'algorithmes pour comprendre et reconnaître la structure d'un morceau
- Utiliser cette structure pour les différencier et les classer

Classification automatique du style musical

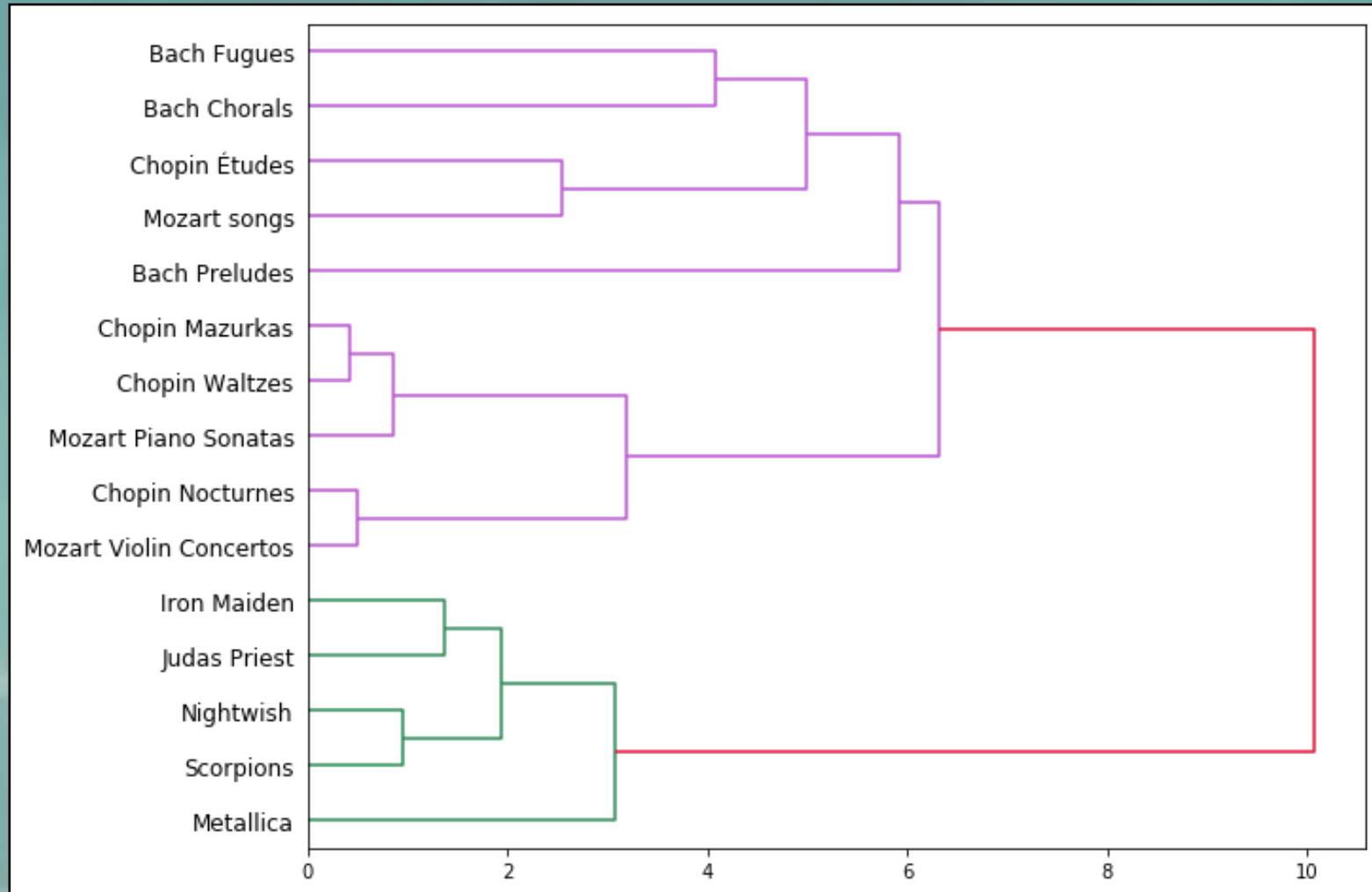
Heavy Metal VS Bach, Mozart et Chopin



Pop VS Bach, Mozart et Chopin



Classifier le style musical



Heavy Metal VS Classique

Ecrire et publier des articles scientifiques

Persistent Homology on Musical Bars

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Abstract. This article presents a new way of building a filtered simplicial complex from a music piece and applying persistent homology in the context of musical analysis. Our approach consists of considering any musical score as the set of its musical bars, which we see as subsets of \mathbb{R}^3 . With this definition, we may consider the Hausdorff distance between two musical bars, which gives us a point cloud from any score, and that allows us to build the associated Vietoris-Rips complex. We will then use barcodes to visualize persistent homology and give an illustration of our construction on a famous movie music piece.

Keywords: Musical bars · Filtered complex · Persistent homology · Barcodes · Musical analysis.

1 Introduction

1.1 Persistent Homology

A filtration of a simplicial complex K is a nested sequence of sub-complexes $\emptyset = K^{-1} \subset K^0 \subset \dots \subset K^N = K$ of K : we call K a **filtered complex**. A simple filtration is presented for instance in figure 1. Starting from a filtered complex, we can compute its simplicial homology (over \mathbb{F}_2) at each **time** of the filtration, and persistent homology gives information about inclusions between the various complexes, as explained in [7]. The associated homology groups $H_*(K^s)$ are characterized by their dimensions, which are called the **Betti numbers**. We can visualize persistent homology on a figure called a **barcode**, where the horizontal axis represents progress in the filtration and a bar that starts at time s and ends at time t corresponds to a generator of $H_*(K^s)$ that is still one for $H_*(K^{t-1})$ but not anymore at time t (see [4]). Barcodes allow us to immediately identify classes that **persist** during the filtration. For instance, barcodes associated to the filtered complex in figure 1 are presented in figure 2, in degrees 0 and 1.



Fig. 1: A filtered complex with 6 times of filtration.

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Fig. 8: The musical accompaniment of *Comptine d'un autre été: L'Après-midi*. These 4 bars consists of 4 arpeggiated chords $Em - G - B - D$ and are played once at the beginning of the score without any melody, from B_1 to B_4 .



Fig. 9: Barcodes for *Comptine d'un autre été : L'Après-midi* in degree 0 (left) and degree 1 (right).

Let us look at the barcode in degree 0 from figure 9: there are several levels of analysis depending of the error margin we choose to take, and the main idea of persistent homology is to focus on the largest bars (those which *persist*), while the smallest ones can be considered as *noise*. In our case, there are 2 bars that stand out when we take an error margin larger than 21%, that means that the corresponding complex has only 2 connected components. One of them corresponds to the last musical bar B_{39} of the score, which only consists of the final chord Em played with whole notes, and the other is a large dimensional complex where all the musical bars are connected together. This first analysis shows that the barcode in degree 0 separates the end from the rest of the piece, which is a start. For $t\%$ with $t \leq 8$, there are only small bars so we ignore them as noise. Between 8% and 21%, there are 5, 6 or 7 classes that seem to last and more precisely, we found that with an error margin of 14%, the associated complex in the filtration looks like in figure 10, which is really remarkable: actually, there are 6 connected components and if we look at the vertices, we see that each one corresponds to a theme of the song, except for B_8 and B_{28} which have a slight different structure than the rest of the first theme.



Fig. 10: The associated complex of *Comptine d'un autre été: L'Après-midi* with an error margin of 14%: each component characterizes a theme of the piece.

Mon travail de médiation scientifique

Ecrire des articles de vulgarisation scientifique

Participer à des événements comme la « Fête des Sciences »

<https://www.tangente-mag.com/article.php?id=7818>



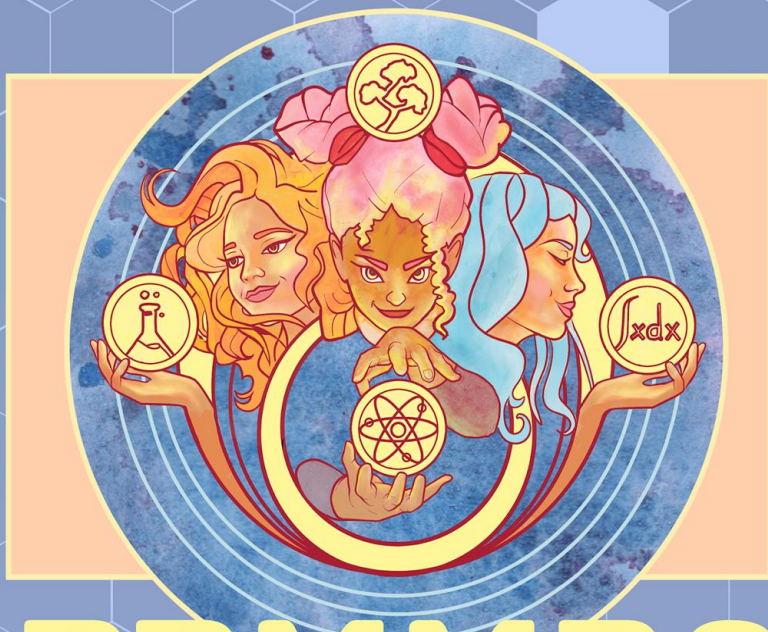
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- Constater les inégalités
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- Apporter des éléments de réponses et des clés pour l'avenir

