

Cosmos-lovers' symphonic guide to the galaxy

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Summary. — In the past, several authors highlighted analogies between classical music and astronomy fundamentals, comparing acoustic and melody features with the characteristics of cosmic objects. However, we believe that a more profound connection between the two disciplines can be explored, considering the harmonic structure and the formal arrangement of symphonic compositions. This new approach can provide a more insightful understanding of both music theory and astrophysics, inspiring both music and physics lovers. In this contribution, we present the format and content of the event “Cosmos-lovers' symphonic guide to the galaxy”, a show imagined and conceived on the basis of this new perspective on the valuable binomial of music and astronomy. During this event, astrophysicist Simone Iovenitti and orchestra conductor Ruben Jais present the analogies between the universe's evolution and symphonies by Rebel, Rameau, and Ives, played by the Symphonic Orchestra of Milan. Images, animations, and videos are projected in the concert hall both during explanations and the live performance, ensuring a very immersive experience to the audience.

1. – A new perspective on music and science

Alongside a scientist, we can embark on a timeless adventure, expanding the boundaries of our experience discovering exotic cosmic phenomena and exploring faraway worlds. Every visited place inspires a specific sound atmosphere, as every traveler knows. This idea led us to conceive the concert named “*Cosmos-lovers' symphonic guide to the galaxy*” (fig. 1), a journey from the birth of the Universe to the depths of the Milky Way, driven not only by science, but also by classical music. In fact, we believe that several concepts in physics and aspects concerning the most profound principles of the universe can be effectively presented to the general public in relation to classical symphonies. In our event, we explained the details of several astrophysics topics, but also the rules of harmony and the basics of music theory. The result is a night show halfway between a symphonic concert and an astronomy lecture, with a full orchestra on the stage playing some of the most famous compositions in the history of music. The event was well balanced between dissemination in physics and music, thanks to the explanations by astrophysicist Iovenitti and orchestra conductor Jais, resulting in an inspiring event for both cosmos

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Fig. 1. – Cover images of the five concerts that we realized between 2019 and 2022, following the approach to science dissemination presented in sect. 1.

and music lovers. The additional emotional component, provided by the projection of images together with live classical music, produced a strong impression on the audience, transforming a cultural activity into an effective educational experience at a very deep level. In particular, this may be very powerful to students, as a part of a learning course.

1.1. *An intimate connection.* – We present a connection between music and science that is different from those already explored in the past [1], and it is probably more effective for dissemination purposes. In particular, we do not use any acoustic or melody features for the comparison between music and physics phenomena, but rather we focus on harmony and the structure of the composition itself, as well as on the formal arrangement of the symphony as a whole. For example, considering the first movement of Beethoven’s Fifth Symphony, we decided to focus on the incomparable repetitiveness of the first four notes: the whole composition is made using the same fragment represented always equal to itself, incessantly. Similarly, in astrophysics, there is a class of compact objects presenting an equivalent behavior, *pulsars*. They are neutron stars emitting a powerful collimated beam of energy rotating off-axis, and hence pointing toward the Earth at a given frequency. The result is a pulsating signal which is the most precise clock in the Universe: its period never changes in time, exactly as the four notes never change in the Fifth Symphony.

The comparison that we make between music and science requires a deep understanding of both astrophysics and music theory, explained respectively by a scientist and an orchestra conductor. We never use trivial analogies, like sweet melodies associated with Venus, or heavy tones associated with Mars. This allows us to analyze in detail also harmony theory, besides astrophysics, hence providing surprising new insights for people interested in both music and research.

1.2. *The format of the show.* – Our event is halfway between a concert and a lecture, and it may be divided into three or four parts. Every part has the following scheme. In the beginning, a scientific topic is explained by the astrophysicist. Afterward, the orchestra conductor introduces the music composition, presenting the peculiar feature recalling the cosmic phenomenon just considered, also with examples played by the musicians. Finally,



Fig. 2. – Left: the scientist explains astrophysics using both images and words, on the stage, next to the orchestra. Right: the orchestra conductor explains music theory also using music sheets if necessary, and examples played by the orchestra.

the orchestra plays the full composition just analyzed. Each part can be dedicated to a specific movement of the same symphony, but also to different compositions. Two parallel conceptual lines are followed in music and physics to link all the different parts together. The stage is set up with the orchestra not exactly in the center, so as to dedicate adequate space to the scientist (fig. 2, left). The background is filled with the projection of images and animations, in order to support the words of both the astrophysics and the conductor with graphic visualizations (see fig. 2), as it is often more effective in public outreach [2].

We presented this format in several events, at the concert hall of the Symphonic Orchestra of Milan, in Italy. *Beethoven and Black holes* (Oct 2019), *A Matter of fugue* (Oct 2020), *Cosmos-lovers' symphonic guide to galaxy* (Oct 2021), *Dark Matter - A symphonic mystery*⁽¹⁾ (May 2022), and *Symphonies through space and time* (Oct 2022). The feedback from the audience was always excellent as reported in sect. 3, while in sect. 2 we present the synopsis of our third event, the main focus of this article.

2. – A symphonic journey through the (history of the) cosmos

Our Universe was born from a melting pot of matter and energy, where nothing existed as we know it today, neither space nor time. The chaos before the cosmos, the era of the primordial mix, gave rise to existence. Baroque composer Jean-Féry Rebel did not know the Big Bang theory, but his symphony “Les Éléments” describes that condition. Music starts with a two-bars cluster, the first one in history. All the minor harmonic scale notes are played together, a violent crash of sounds, sudden and terrible. Afterward, like cracks on a broken mirror, voices run away from the acoustic smash, dispelling the harmonic fog, and giving rise to the distinctive elements of the composition. As music arises from the primordial mixture that filled the concert hall, so nuclei began to exist after the hot quark-gluon plasma that first dominated the Universe.

After the initial nuclear synthesis, it took a long time for the first atoms to form. Today, we can observe the relic light from that period, studying the cosmic background radiation, the farthest object that our telescope can reveal. In the following, gravity determined the collapse of those atoms into the first stellar objects. Hits, flashes, interactions, and the first collapsing particles gave rise to gigantic structures, the stellar component of the growing universe. Exactly what happens in Rameau’s *Zais Overture*:

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raw fragments colliding with each other produce the harmonic elements of a growing symphony.

The secular stability of stellar objects allowed them to take part in the dynamics of larger and more articulated structures, the galaxies. Despite their size and complexity, they are persistent and long-lasting, thanks to the balanced spatial arrangement of their components (stars, gas, dust, and dark matter). The harmonious result is given by the three-dimensional arrangement of the sources, which is exactly the key feature of Giovanni Gabrieli's "Cori Battenti", written for St Mark's Basilica in the XVI century, forerunning the Venetian polychoral style.

At the end of such a symphonic journey across the universe, it is disorienting to get back to our little planet, having explored difficult concepts and exotic phenomena, and broken the limit of imagination, both in spacetime and music. Fortunately, the guide has a remedy for such sickness: *don't panic!* [3] and consider the most peculiar characteristic of human beings: curiosity. We are conscious matter studying itself, longing to understand and explore what surrounds us, making research both in music and physics. The symbol of this process is undoubtedly the Voyager spacecraft, the furthest product of human beings in the cosmos, sent to probe the interstellar environment. Considering its (*our!*) heroic journey into the vastness of the universe, the long notes of the last piece resonate like a soundtrack in the concert hall, while the title of the composition, by Charles Ives, reminds us why it all began, "The Unanswered Question".

3. – Conclusion

In general, the feedback from the audience was excellent. People were enthusiastic about this event and they asked us to repeat the performance. We saw many families and young people in the audience, and several teachers with their students. This activity also had a long echo on social media, television, and newspapers. The key feature is undoubtedly the equal alternation between music and physics, as it is not a conference followed by a concert, but rather a fair blend of the two. This balance ensured to capture the attention of both cosmos lovers and musicians, while innovative aspects attracted both experts and the general public.

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