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A density valley across stellar types

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The radius valley separating super-Earths from mini-Neptunes is a fundamental benchmark for theories of planet formation and evolution. Observations show that the location of the radius valley decreases with decreasing stellar mass and with increasing orbital period. Here, we build on our previous pebble-based formation model. Combined with photoevaporation after disc dispersal, it has allowed us to unveil the radius valley as a separator between rocky and water-worlds. In this study, we expand our model for a range of stellar masses spanning from 0.1 to 1.5 $M_\odot$. We find that the location of the radius valley is well described by a power-law in stellar mass as $R_{\rm valley} = 1.8197\ M_\star^{0.14(+0.02/-0.01)}$, which is in excellent agreement with observations. Additionally, we note that the radius valley gets filled towards low stellar masses, particularly at 0.1 – 0.4 $M_\odot$. This is the result of orbital migration occurring at lower planet mass for less massive stars, which allows for low-mass water-worlds to reach the inner regions of the system, blurring the separation in mass (and size) between rocky and water-worlds. Furthermore, we find that for planetary equilibrium temperatures above 400 K, the water in the volatile layer exists fully in the form of steam, puffing the planet radius up (as compared to the radii of condensed-water worlds). As with Sun-like stars, we find that pebble accretion leaves its imprint on the overall exoplanet population as a depletion of planets with intermediate compositions (i.e. water mass fractions of $\sim$ 0–20%), carving an planet-depleted diagonal band in the mass-radius diagrams.

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Probing a laboratory asteroid model: Mechanical characterization under loading-unloading cycles

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This study examines the mechanical properties of asteroids on a laboratory scale, focusing on their relevance in space mission design, Earth collision hazard assessment, and understanding collisional processes. Following the NASA-DART mission, the effectiveness of deflection relies on factors like cratering events, momentum distribution in ejecta, and the propagation of impact-induced seismic waves within asteroids.

Our comprehensive laboratory-scale characterization of granular media in dynamic regimes offers a cost-effective alternative to in-situ measurements. Scaling experiments by approximately 300-fold simulates a Dimorphos-sized asteroid, revealing particle sizes of 5 to 50 cm as observed on the mission. Micro-gravity conditions on asteroids yield unique mechanical properties challenging to replicate on Earth. While non-realistic, our experiments aid in understanding seismic wave propagation's role in material expulsion within asteroids, contributing to the comprehension of active asteroids and enhancing our knowledge of asteroid interiors and boulder distribution.

We observe pressure waves with frequencies ranging from 200 to 500 Hz. Independently of the granular media, glass beads (artificial, spherical), sand (natural, irregular), and gravel (natural, irregular), the wavespeed follows a power-law relationship $v \propto p^{1/2}$, and indicates that the speed of seismic body waves is independent of the origin mechanism, suggesting safer wave-generating methods for low-gravity experiments instead of risky impact devices.

The equivalence between wave propagation from impacts and shaker-born perturbations is valuable for non-impacted testing to assess granular material properties in low-gravity conditions. With the upcoming Hera mission to the Didymos-Dimorphos system in 2027, aiming to study internal asteroid structure, our research lays a foundation for a deeper understanding of asteroid interiors and boulder distribution.

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The influence of stellar activity on the atmospheric properties of hot Jupiters

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Hot Jupiters are extremely irradiated gaseous exoplanets with orbital periods less than 10 days. Since they are exoplanets so close to their stars, it is reasonable to assume that there is a stellar influence on the atmosphere of these objects. It was previously shown in the literature that strong magnetic fields and high energy particles from the stellar chromosphere can affect hot Jupiters' atmospheres by causing mass losses and subsequently orbital decay. We analyze the hypothesis that hot Jupiters without thermal inversion orbit active stars, while hot Jupiters with inversion orbit inactive stars. We use a larger sample and updated data to reproduce two approaches from previous works that try to classify hot Jupiters according to their brightness temperatures in five infrared bands: 3.6 μm, 4.5 μm, 5.8 μm, 8.0 μm (Spitzer), J, H and Ks (2MASS). We also investigated the relationship between the incident radiation and the presence or absence of thermal inversions. We found a good correlation (Pearson r coefficient ≥ 0.6) between 5.8 μm and H brightness temperatures and the chromospheric activity index $\log R'_{HK}$. However, we did not find a clear separation between exoplanets with and without thermal inversion as a function of stellar activity. We also found that the most irradiated exoplanets have thermal inversion, while the least irradiated ones do not.

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Study of the dissipation times of gaseous disks in stellar populations

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Protoplanetary disks are the sites of planet formation. For this reason a correct modelling of protoplanetary disks is key to understanding planetary formation. In this work we present a disk population synthesis study aimed at reproducing the available observable properties of protoplanetary disks. We consider that disks evolve by viscous accretion and internal photoevaporation. The initial conditions, such as the masses and sizes of the discs, follow statistical distributions inferred from observations. We analyze the impact of stellar mass distributions and star formation rates on the time evolution of the fraction of stars with disks, and on the stellar mass accretion rates.

Our models show that, because massive stars dissipate their disks faster, the observed fraction of stars with disks in star-forming regions is dominated by disks around low-mass stars. The lifetime of protoplanetary discs has an uncertain distribution function, to calculate the average lifetime of disc on star formation region we consider that it follows a Log-normal distribution. From our models, we obtain a median disk lifetime of 4.2 My, showing very good agreement with observations.

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Variability of water vapor in the internal atmosphere of Mars associated with the solar activity cycle

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This work explores the intrincate relationship between Mars' atmospheric variations and dynamic solar activity patterns. We focus on periodic oscillations in H_2O vapor and the Pectinton solar flux index in the $\lambda = 10.7$ cm radio band, around the characteristic 11-year solar cycle. Periodic Mars activity was studied using data from Mars Express' SPICAM instrument spanning 2004-2018. The Lomb-Scargle Periodogram method was applied to analyze the power spectra of both signals around this period, calibrated using peaks associated with the seasonal Martian cycle. This method was validated by analyzing power spectra of chemical species abundances in Earth's atmosphere, obtained from the NRLMSISE 00 empirical model provided by the National Oceanic and Atmospheric Administration (NOAA). Model executions reproduced chemical abundance data for various atmospheric species (N_2, O_2, N, H_2, Ar, and He) at two reference heights (upper mesosphere and low ionosphere) over a 1961-2021 time span. Results suggest a connection between variability in H_2O vapor concentration in Mars' atmosphere and fluctuations in the Pectinton solar flux index. We propose the Lomb-Scargle Periodogram method as a heuristic for studying oscillatory activity in planetary atmospheres with non-uniformly sampled data. While our results provide valuable insights, further analysis, cross-referencing with data from different orbiters, is required to deepen our understanding of these findings in the fields of planetary climatology and atmospheric physics.

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Like a wrecking ball: understanding giant planets as the key to finding Earths

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Jupiter-like planets are the key to understanding Earth-like planets. Their presence can disrupt the orbits of inner habitable worlds, or deliver life-sustaining water. While the search for Earth-like planets orbiting nearby stars garners the most attention, it is critically important to understand the presence and properties of giant planets in those systems. In the next decade, three space missions will provide unprecedented new opportunities for understanding the nature of these Jupiter analogs: Gaia, the James Webb Space Telescope, and the Nancy Grace Roman Space Telescope. We aim to take advantage of the multi-messenger synergy of these observatories, in combination with Australia's unique Minerva-Australis telescope array, to obtain a complete picture of the nearest extrasolar planetary systems. Dozens of cold giant planets are known from radial-velocity planet searches. But their true masses remain unknown due to the limitations of the technique. In Data Releases 4 and 5 (2025/26) the Gaia space astrometry mission will deliver the critical measurements of 3-dimensional architecture for these planetary systems. Combined with the minimum masses obtained from radial velocities, we will obtain the true masses of those planets. Our Minerva-Australis observatory is fully dedicated to radial-velocity measurements; it is the only such facility in the Southern hemisphere. We will use these data to better characterise nearby Jupiter analogs for which true masses and orbital inclinations can be derived with forthcoming Gaia data. With detailed knowledge of the properties of those giant planets, we can model the extent to which those planets deliver water to inner Earth analogs via comet impacts. These Jupiter analogs will also be prime targets for direct imaging by JWST and Roman.

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Ejection experiment in soft granular media

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Asteroids have been shown to be composed of granular media, Tancredi et al. (2012) predicted the creation of dust clouds at low escaping velocities post-impact. Their study proposed that a layer of particles shocked from below could cause particles to ascend from the surface, a phenomenon known as the "cocoa effect".

Our research focuses on exploring particle velocities ejected from soft granular media, specifically rubber particles sieved into various sizes. The primary objective is to understand the behaviour of the cocoa effect at a laboratory scale, emphasizing the measurement of both height and velocity reached. Rubber serves as our chosen medium due to its notably slower wave velocity compared to harder media, facilitating movement capture through high-speed cameras. The experimental setup entails an acrylic prism filled with rubber, positioned atop a shaker with an attached accelerometer. We varied the shaker's pulse amplitude. Particle movement is recorded with a high-speed camera and analysed using Particle Image Velocimetry (PIV) and correlation techniques (phase tracking and time correlation).

Initial findings provide insights into the beginning of lofting and velocity variations within the column of material. Notably, the analysis reveals a correlation between the amplitude and slope of the observed phenomena. A larger amplitude corresponds to a steeper slope. To validate our observations, correlation tracking was employed, further substantiating that larger slopes indeed align with more substantial amplitudes. These results contribute to a comprehensive understanding of the dynamics involved in lofting within the soft granular medium, laying the groundwork for further investigation and refinement of our experimental approach.

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What is the frequency of meteorite falls? Is there a preferred day?

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Meteoroids are solid natural objects of a size roughly between 30 μm and 1 m moving in interplanetary space, that can reach the Earth upper atmosphere producing a noticeable phenomenon: a meteor. They might survive the meteor phase when passing through the atmosphere, and eventually reach the surface as meteorites. If recovered after observations of their passage they are called falls, whereas, if found by chance they are called finds. As of 20/11/2023 there are 1,218 recorded falls worldwide, with official names in the Meteoritical Bulletin Database. A subgroup among the falls are those that directly affect humans or their belongings (damaging falls). A meteoroid stream is a group of meteoroids with common orbits and origins (e.g., from the fragmentation of an asteroid), and is of great relevance because it might indicate the presence of a larger body, yet to be discovered. The aim of this work is to analyze the temporal distribution of meteorites, calculate how many meteorite falls per year, and how many of them are damaging. We determined if there is any preferred moment of the year with more meteorite falls. The frequency of falls per day over the entire Earth was calculated as a function of the day of the year and solar longitude; and compared with a Poisson process in order to look for dates with higher frequency than expected. From our analysis, an average rate of $\sim$7.82 falls and $\sim$1.72 damaging falls on urban Earth per year was calculated. Subsequently, $\sim$6,014 falls per year over the entire Earth's surface, and $\sim$1,777 falls per year over Earth's landmass were estimated from satellite data. No peaks in the distribution tail were observed, therefore, the presence of a meteoroid stream cannot be asserted. There is no particular day of the year with a higher fall rate, hence, it is likely that there are no highly populated meteoroid streams.

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Coorbital dynamics: a semi-analytical approach to study equilibrium points in resonant coorbital configurations under extreme inclination and/or eccentricity

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Co-orbital orbital dynamics is really important to understand some aspects of small body populations in our Solar System. The most studied case in the literature are Jupiter Trojans. Not all planets have known coorbitals. For example, Venus, Earth and Mars have confirmed ones but their stability has been a matter of some debate in the literature. There are several co-orbital motion types: tadpoles, horseshoes and quasi satellites. Remember that in the classic planar circular case we only have two tadpoles which librate around $\pm 60°$, these are called Trojans and are located in usually called L4 and L5 equilibrium points. It is important to notice that when the eccentricity or inclination of the secondary body grows those points change their position. This semi-analytical approach can be used to study any resonance such as 1:1 in this case. It provides a numerically integrated Hamiltonian and equilibrium points, as well as resonance widths and periods of librations. The advantage of using this theory is that we do not have restrictions in eccentricity nor inclination except for almost circular orbits where the hypothesis of the model fails. Our objective is to test the model under extreme conditions. Using it, we have mapped the location of equilibrium points for high eccentric and/or inclination orbits and searched for possible known asteroids in the NASA Horizons catalog that match this type of orbits. Furthermore, some problems can be modeled with this work such as pollution in white dwarf spectra. It has been proposed that post main sequence evolved small body population falling into the star due to resonant perturbations in high eccentric orbits could explain this. Also, we can apply this theory to study systems with two co-orbital planets such as the recent evidence for exoplanet system PDS 70 could indicate.

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Search for cometary activity in transitional objects using archival images and new observations: preliminary results

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We present the monitoring of a set of Asteroids in Cometary Orbits (ACOs) and Activated Asteroids (AAs), which are part of transitional objects: bodies that do not fully fit the traditional categories of asteroids and comets. Using archival images from the Dark Energy Survey (results not revised by the Collaboration yet), ESO's Very Large Telescope, and Instituto de Astrofísica de Canarias, alongside recent data from Observatório Astronômico do Sertão de Itaparica, we employ two distinct techniques to detect signs of cometary activity: i) the comparison of the surface brightness profile of the objects with those of field stars, ii) the study of the reduced magnitude vs. the heliocentric distance in search of increases in brightness, using data from the Minor Planet Center, and those obtained in the observations. We analyze the profiles of 133 ACOs and seven AAs and the reduced magnitudes of all the ACOs (705). Eleven ACOs presented a deviation in the surface brightness profile and/or in the reduced magnitude. We found a very small percentage of objects with signs of low-level activity, which would rule out a slow transition from active to inert. Four AAs were active in the images, three being coincident with the existing reports, while in the case of P/2015 X_6, we extended the activity period in 19 days. We could observe that the episodes of activity are very restricted in time and do not always occur in the same region of the orbit.

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Tidal evolution in dwarf planets systems as an application of the creep model

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To date, there are five confirmed dwarf planets, four of which are located in the trans-Neptunian region, namely: Pluto, Eris, Haumea, and Makemake. All four have natural satellites. It is well known that Pluto-Charon's rotations are synchronized with the orbital motions. Eris and Dysnomia also have their rotational and orbital periods synchronized, respectively. This synchronous state is a natural consequence of tidal interaction between the dwarf planet and its main satellite. In this work, we propose to investigate the orbital evolution of the tides in Pluto-Charon and Eris-Dysnomia systems using the creep model, where the main parameter is the viscosity attributed to the deformed body. Regarding the action of the tides on both bodies, we integrated the equations for the mean variations of semi-major axis, eccentricity, and rotation velocity over Gyr timescales, to investigate when and how the system could have entered into synchronous motion. In addition, based on the equations of the creep model, we performed a parameter space analysis to obtain the most influential parameter on the orbital evolution of dwarf planets and their satellites.

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Reviewing cometary-like asteroids in view of the DART experiment

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Several objects in asteroidal orbits have presented comaes and tails like the ones presented by comets. There are at present (12/2023) 46 objects that have presented, at least for a brief period, this cometary-like appearance. These objects are generally coined "Active Asteroids", implicitly implying that some kind of on-going endogenous or exogenous active process is the mechanism that produce the long-lasting tails. Nevertheless, what we observe is that those asteroids are temporally dressed as comets. Several hypotheses have been proposed to explain the "activity" of these objects.

Lessons from DART: The NASA-DART experiment gave us an opportunity to review our knowledge of this population. Following the impact of the space probe against asteroid Dimorphos on September 26, 2022, several thousand tons of material were ejected at a wide range of velocities. Tancredi et al. (2023) dubbed the DART experiment as the creation of the first artificial "Active Asteroid". They proposed that the production of a large amount of low-speed ejected material could be described by the "cocoa effect": the lofting of small particles from the top of a dust layer by shaking the ground. The seismic shaking, combined with the "cocoa effect," may lead to the ejection of particles from a significant portion of the affected hemisphere. They predicted a brightness increase due to a slowly moving dust cloud, the obscuration of Dimorphos' surface by this cloud, and the generation of a long-lasting tail; which were confirmed by the close-by observations of LICIACube, as well as long-range tracking from HST and the ground. By July 2023, over 250 days after impact, the tail was still visible.

Based on these results, we reviewed the relevance of the different mechanism proposed to explain the appearance of the population of asteroids temporally dressed as comets.

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Qualitative analysis of the dynamical evolution of planetary systems

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Discoveries of extrasolar planetary systems have shown that the configuration of our Solar System is an exception to the rule given the number of systems with high relative inclinations, large eccentricities and high mass planets in orbits with periods of hours. Due to these peculiar characteristics, our goal is to understand the processes that led planetary systems to acquire such characteristics, through mutual gravitational interaction and with the proto-planetary disk. To verify the quality of the observational data and the stability of the planetary systems in periods of at least 1 Myr, we use the concepts of Hill Stability (Marchal & Bozis (1982) and Gladman (1993)) that consider the configuration of the systems in terms of total energy and orbital angular momentum; to evaluate their secular movements we work with the construction of Representative Plans that bring with them information of the long-period behavior of the system, based only on the mass ratio of the planets and the ratio of their semi-major axes; To analyze the temporal evolution, we use the theory of semi-analytical perturbation (Michtchenko & Malhotra, 2004) that allows us to explore systems of high eccentricities by not working with series expansions of the Disturbing Function. We work with models that simulate the process of planetary migration (Michtchenko & Rodríguez, 2011), which change the orbital elements in a forced way, seeking to relate the migration trajectories with known processes, interaction of the planet with proto planetary disk, accretion of matter and tidal effects. Using the stability criteria, we selected some planetary systems to start the analysis and, after verifying their secular behavior, we started the simulations of migratory processes to understand through which configurations the system passed until arriving in the current state, considering only the variation of the total energy of the system and the orbital angular momentum.

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A local approach of planetesimal fragmentation applied to planet formation

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One of the challenges in planetary formation models is, including the main physical phenomena in that process, to explain the diverse architectures of planetary systems observed to date. The modelling of collisions and planetesimal fragmentation is key to reproducing planetary formation and evolution correctly. Our previous works show that the inclusion of a detailed model of planetesimal fragmentation, considering different compositions and relative velocities of planetesimals, may inhibit or favour the formation of giant planet cores, drastically changing the final planetary system architectures. However, in global planetary formation models, the detailed modelling of these processes is extremely expensive from a computational point of view. Generally, these models include the planetesimal fragmentation process locally. In this work, we study a local approximation of this process that simplifies the phenomenon numerically, significantly reducing the computing time required for our simulations. We compare these results to our detailed model of planetesimal fragmentation applied to giant planet formation and contrast it with other local approximations in the literature to determine its validity.

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The AGE-PRO ALMA Survey: A glimpse into the gas evolution in protoplanetary disk

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The fundamental question of how the gas and solids in protoplanetary disks evolve with time remains unanswered. However, the ongoing ALMA Large Program AGE-PRO ("ALMA survey of Gas Evolution in PROtoplanetary disks") was designed to answer this question for the gas component. AGE-PRO will trace the evolution of gas disk mass and size throughout the lifetime of disks, using a well-defined sample of 30 disks between 0.1 and 10 million years old. By studying a large sample of disks at different ages, AGE-PRO will be able to identify the key factors that drive the evolution of gas disks and to better understand how these disks ultimately give rise to planets.

Here, we present the preliminary analysis on Upper Scorpius and Ophiuchus, the oldest and youngest regions in our sample, respectively. For Upper Scorpius we have imaged gas and continuum emission, and generated disk-integrated line fluxes and radial intensity profiles for all lines and for the continuum, in all 10 disks selected. ^{12} CO emission is ubiquitous across the entire sample, with detection in all observed sources. In contrast, transitions of its heavier isotopologues, ^{13}CO (2-1), and C^{18}O (2-1), exhibit lower detection rates of 60% and 40%, respectively.

Additionally, we have analyzed the young Ophiuchus star forming region to examine the nature of the gas rotation with CO isotopologues. We are deriving rotational profiles from the PV diagrams and the size of Keplerian disks for Class I/FS sources.

These results will establish a foundation for understanding the global structure and evolution of protoplanetary disks. This will provide essential context for future in-depth studies of planet formation processes in disks.

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Rotational period determination of fortuitous asteroids

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In this work we present the results of the photometric analysis of 11 asteroids whose rotation period has not been estimated and which we consider to be fortuitous as they were not the main objective of the photometric observations. They were present in the same field of view as the asteroid of study and showed sufficient brightness for photometric analysis. The images analyzed correspond to 23 nights in 2022, and were obtained from the National Astronomical Observatory of San Pedro Mártir, using the 84 cm telescope. Image processing, aperture photometry, and differential photometry were performed to calculate light curves. Subsequently, a search for the value of the corresponding rotation period was carried out using Fourier series analysis, employing a computational program that performs a rotation curve fitting. The complete data is available in: here.

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Evaluation of the AUTOBOL algorithm withh a sample of events detected by the BOCOSUR Network in Uruguay

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BOCOSUR is a network of 20 stations deployed in Uruguay to detect fireballs (meteors brighter than Venus). Autobol is a machine learning-based algorithm that is capable of processing images and detecting events from a series of videos. The learning process of the algorithm begins with a manual classification of videos as with and without fireballs, this is essential because by choosing good candidates for videos with fireballs the learning is more specific. RANSAC "RANdom SAmple Consensus" is responsible for estimating the parameters of a mathematical model in Autobol.

Since 2019 we have deployed a network of stations with allsky cameras for the detection of bright meteors (fireballs). By October 2021, 6 stations were installed in the south of Uruguay, in what made up the first stage of the Red de Detección de Bólidos del Cono Sur (BOCOSUR). The stations run an application developed by our group (see Caldas et al. in this conference), which detects any change in brightness in consecutive frames. Therefore, a classification should be made between videos with and with out fireballs. In 2022, a group of Electrical Engineering students (Ballestrino et al. 2022) developed an algorithm based on machine learning for the automatic classification of the videos, using the classification we had done as a training base. To train the Autobol package, we used the manual classification of $\sim$ 8000 videos, where 363 of them have fireballs. In this poster we present the results of applying these predictive classification models to a database of over 250,000 videos. We present statistics on the performance of the network and the classification algorithm.

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Experimental simulation of a solar UV environment on mars and its effects on germination and photosynthetic pigment content of Chenopodium Quinoa

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Mars exploration has become a human goal in recent years, as the possibility of colonizing this planet opens up space for research and innovation in fields such as astronomy, astrophysics, astrobiology, among others. International agencies have directed their efforts to conduct various reconnaissance missions to Mars, with the aim of not only preparing for future human existence on the red planet but also ensuring food sustainability. Considering the above, this work has the main goal of simulating an experimental environment that replicates the environmental conditions of Mars related solely to solar ultraviolet radiation levels and establishing their effect on the germination and photosynthetic pigment content of *Chenopodium quinoa*. We focused on establishing the effect of these conditions on the germination and photosynthetic pigment content of *Chenopodium quinoa*, in order to make a pilot study for future colonization and subsistence on the planet. It was found that UV radiation stimulates the emergence of seeds from different *Chenopodium quinoa* materials, acting as a directed photomorphogenic signal. Specifically, at shorter wavelengths, the germination percentage was higher compared to normal conditions. Something very similar happened with the plants, where treatments with UV resulted in notable increases in the concentration of total chlorophyll at short wavelengths, showing an "automatic" increase in both materials. Further study of these behaviors in more extended experiments and with materials from other plant species would be worthwhile.

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