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Edited by Vladimir A. Srećković, Aleksandra Kolarski,
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SCIENTIFIC RATIONALE

The primary objective of this conference is to bring together researchers and professionals from various disciplines to examine innovative methods and exchange ideas on the successful integration of knowledge across various fields, from solar-terrestrial interactions, across geophysics, astrophysics, astronomy, plasma physics, to other Earth-related disciplines such as physical geography, geodesy, environmental studies etc. By engaging in plenary sessions and targeted mini-projects, participants will collaborate to create extensive resolutions that tackle numerous topics across vast scientific fields. This will lead to the production of joint publications in reputable scientific journals.

Venue

Institute of Physics Belgrade

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[https://doi.org/10.69646/aob241201]
[Plenary Invited Lectures]

On the Stark broadening of spectral lines of ionized copper

Milan S. Dimitrijević[1,2*]

[1]Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
[2]ILERMA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, F-92190 Meudon, France

[*]Correspondence: mdimitrijevic@aob.rs

Abstract: Atomic data are of great importance for modelling and investigations of different plasmas in astronomy, laboratory and technology. In particular, Stark broadening data or data on widths and shifts of spectral lines broadened by collisions with charged particles are needed in a number of different topics, like in astrophysics, for inertial fusion experiments, laser design and development, laser-produced plasma research, different plasmas in technology and industry etc. Stark broadening data for lines of onized copper are needed for example for diagnostics, spectral analysis, modelling and optimization of laser-produced plasma in front of copper target in photon and ion irradiation of metal nanoparticles and other copper-based experiments involving plasma. Such data are of interest also e.g. for stellar abundance determination, stellar atmosphere modelling etc., since Cu ines have been observed in spectra of various stellar types. Recently, electron-impact (Stark) full widths at half intensity maximum for 22 spectral lines of singly charged copper ion (Cu II) have been calculated (Dimitrijević, 2024) by using the modified semiempirical method (Dimitrijević and Konjević, 1980, see also Dimitrijević, 2020). The calculations have been performed for an electron density of 10^{17} cm^{-3} and for a temperature range from 5 000 K up to 80 000 K.

The obtained results, have been used to demonstrate similarities and regularities of Stark widths of Cu II spectral lines within a multiplet, a supermultiplet and a transition array. The obtained results have also been compared with the results of experiments and other theoretical data. Here, we will present the corresponding article (Dimitrijević, 2022) and the obtained results.

Keywords: Stark broadening, Cu II, line profiles, atomic data, atomic processes

Acknowledgement

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References

Dimitrijević, M. S. (2020) 'Forty Years of the Applications of Stark Broadening Data Determined with the Modified Semiempirical Method', *Data,* 5, 73.

Dimitrijević, M. S. (2024) 'Stark Broadening of Cu II Spectral Lines' *Physica Scripta*, in pres, DOI: https://doi.org/10.1088/1402-4896/ad7c94

Dimitrijević, M. S. and Konjević, N. (1980) 'Stark widths of doubly- and triply-ionized atom lines' *J. Quant. Spectrosc. Radiat. Transf.* 24, 451–459.

Invited Lectures

[https://doi.org/10.69646/aob241202]
[*Invited Lecture*]

Earth Observations and VLF: an integrated Approach to powerful Solar Flare Events

Aleksandra Kolarski[1*]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11000 Belgrade, Serbia

*Correspondence: aleksandra.kolarski@ipb.ac.rs

Abstract: Powerful solar flare events across last three solar cycles were analyzed through their geo-effectiveness, based upon remote sensing technique, using ground-based receiving system for registration of Very Low Frequency (VLF, 3-30 kHz) radio signals located at the Institute of Physics Belgrade, in Serbia, and solar soft X-ray flux (0.1-0.8 nm) data from Geostationary Operational Environmental Satellite (GOES) archive database. Earth's lower ionospheric perturbations of mid-latitudinal region over Europe were examined, based on amplitude and phase delay disturbances simultaneously monitored and recorded on several VLF signals recorded by Belgrade receiver (BEL; 44.85° N, 20.38° E). In order to obtain electron density height profiles throughout entire lower ionospheric region related to selected solar flare events of significant geo-effectiveness, three independent approaches of numerical simulations were applied, and not only to the moments of selected solar flare events' maximal X-ray flux irradiances, but also their entire time evolution intervals were analyzed and modeled, with main results presented in this research.

Key words: Solar activity, X-class flares, lower ionosphere, VLF perturbations

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[Invited Lecture]

Daytime and nighttime VLF signal classification utilizing machine learning methods

Filip Arnaut[1*]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Republic of Serbia

*Correspondence: filip.arnaut@ipb.ac.rs

Abstract: The automatic classification of ionospheric very low frequency (VLF) signals is a current research endeavor aimed at creating a machine-learning (ML) methodology capable of differentiating among various influences on VLF signals, including solar flares, VLF receiver malfunctions, nighttime VLF signals, and other factors. This communication discusses the enhancement in ML classification of daytime and nighttime ionospheric VLF signals, including the different methodologies, data processing, and various processes that demonstrated improvement over prior research.

Keywords: Machine learning, data-driven modelling, anomaly detection, geophysics.

Introduction

The automatic classification of very low frequency (VLF) signal disturbances and characteristics through machine learning (ML) techniques is a subject previously presented (Arnaut et al., 2023; Arnaut, Kolarski, 2023; Arnaut et al. 2024) and remains an area of active research. VLF signals generally capture the impacts of solar flares, instrument malfunctions, erroneous measurements and other, as well as the variation between daytime and nighttime signals.

Typically, the nighttime signal exceeds the daytime signal, with the exception of the terminator, which is characterized by a minor decline in the signal prior to a pronounced ascent, ultimately stabilizing at a level exceeding that of the daytime signal. The ongoing research focuses on the automatic classification of diverse effects on the VLF signal, aiming to establish a method that minimizes error in this classification process. This research demonstrates the advancements in the classification of daytime and nighttime VLF signals, the modifications implemented during this period, and the resultant outcomes.

Methods and data

The primary distinction in the methodology between prior research and the current study is that data labeling in the latter was conducted on an individual case basis. Daytime and nighttime conditions were previously established through conditional labeling based on the local receiver time. The transition from imprecise conditional labeling to manual data labeling enhanced data quality, thereby improving the predictive capabilities of models and facilitating a more accurate differentiation between daytime and nighttime conditions.

Secondly, the feature list was expanded to include weighted moving averages, in addition to the previously employed statistical features, whereby data points nearer to the instance under analysis are assigned a greater weight coefficient. Furthermore, the class balancing approach of random undersampling was replaced with the Synthetic Minority Oversampling Technique (SMOTE), which ensures that no data is discarded, as occurs in random undersampling. The random forest model was ultimately replaced by the extreme gradient boosting (XGB) model, utilizing the random search hyperparameter tuning method for tuning of the number of estimators and the learning rate.

The model's predictions underwent cluster analysis, as the nighttime signal extends over a longer duration; clusters of relatively few consecutive nighttime labels were reclassified using the cluster analysis. The outcomes for both raw model predictions and predictions reclassified through cluster analysis are presented in this study.

Results and discussion

As previously stated, the training dataset was balanced using the SMOTE technique, which ensured that no data points were omitted, while the minority class (specifically, the nighttime signal class) was oversampled. The original distribution in the training dataset was 70-30, favoring the daytime signal; therefore, SMOTE was employed to oversample the minority class.

The hyperparameter tuning method chosen was random search for both the number of estimators (ranging from 100 to 1000 in increments of 20) and the learning rate (ranging from 0.01 to 0.2 in increments of 0.01). The most effective model exhibited 840 estimators and a high learning rate of 0.2. The initial model exhibited accuracy, precision, and F1-score values of 0.79, 0.71, and 0.78, respectively, while the AUC value was 0.8, indicating an acceptable capacity of the model to differentiate between the classes.

Figure 1 illustrates a dataset comprising 1000 data points, specifically in minute intervals, pertaining to the NLK-Sheridan transmitter-receiver pair, where the nighttime signal is represented (true class labels are shown in the upper panel and predicted labels in the middle panel). The model's raw output exhibited relatively satisfactory classifications, demonstrating moderate predictive capability to differentiate between nighttime and daytime VLF conditions in the provided example. The classification of the daytime-to-nighttime terminator and the segment of the signal immediately following the nighttime-to-daytime terminator could be further improved as to align more with the true classifications.

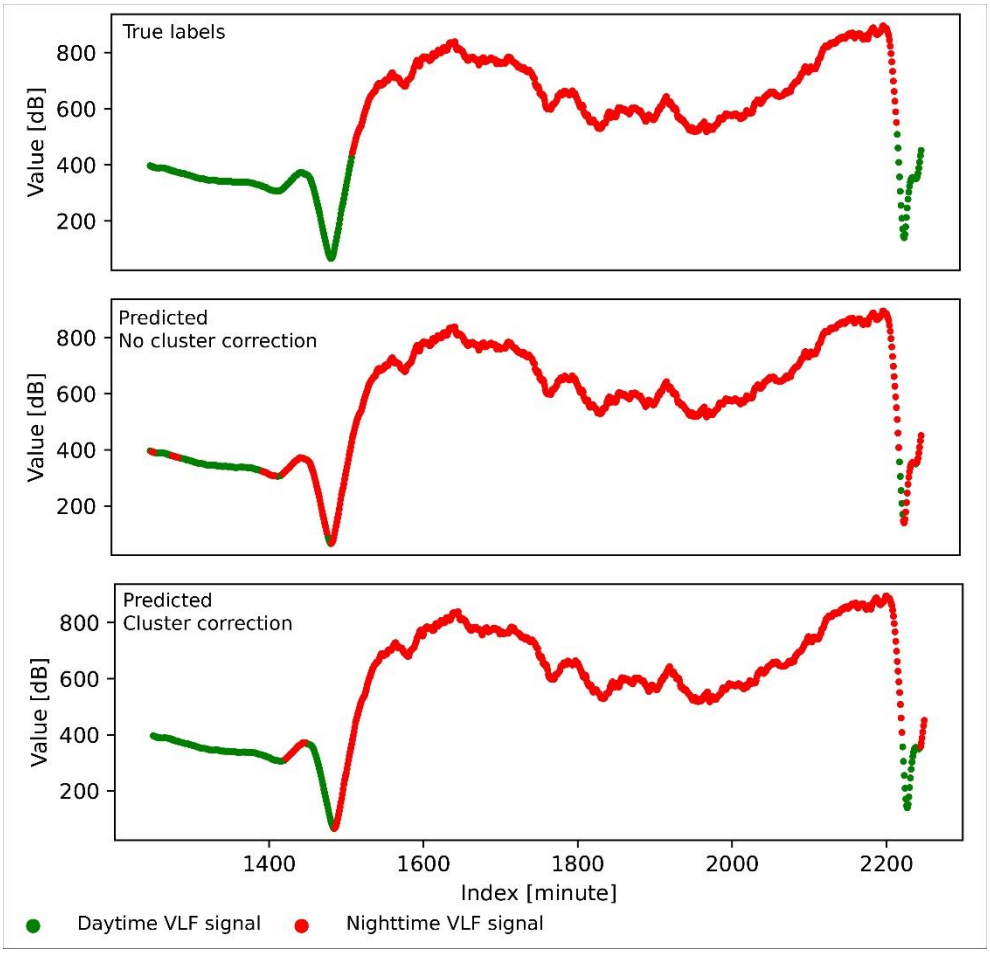

Figure 1. True daytime and nighttime labels (upper panel); Predicted labels without the cluster correction (middle panel); Predicted labels with the cluster correction (lower panel)

Cluster analysis was utilized to correct the minor groups of nighttime labels in the predicted signal. The cluster analysis statistics revealed a significant positive skew in the distribution of cluster lengths, suggesting that the model generates a considerable number of brief nighttime predictions. Conversely, the nighttime signal is expected to be present for a longer duration; consequently, all clusters with a consecutive prediction length of fewer than 25 were

reclassified as daytime signals. Figure 1 (bottom panel) illustrates the reclassification of small clusters previously identified as nighttime signals to daytime signals. The cluster analysis functioned as a corrective measure in this instance and exhibited satisfactory characteristics.

The comparison of evaluation metrics between cluster-corrected and non-cluster-corrected values reveals relatively similar results, occasionally favoring the cluster-corrected values (Table 1). The precision and F1-score for the nighttime class exhibit increased values, whereas the recall parameter shows a lower value for the nighttime class in the cluster-corrected predictions.

Table 1. Comparison between evaluation metrics for the non-cluster corrected and the cluster corrected predictions

	Prec. NC	**Prec. C**	**Rec. NC**	**Rec. C**	**F1 NC**	**F1 C**
Daytime class	0.88	0.86	0.74	0.82	0.8	0.84
Nighttime class	0.71	0.77	0.86	0.82	0.78	0.8
Macro averaged	0.8	0.82	0.8	0.82	0.79	0.82
Weighted averaged	0.81	0.82	0.79	0.82	0.79	0.82

NC- No cluster C- Cluster

The integration of the cluster correction yielded satisfactory results; however, it requires additional refinement to fully automate the process and produce improved, more precise predictions.

Conclusions

The complete automation of ionospheric VLF signal classification will require considerable time and extensive research effort. This communication presents the enhancement of ML classification for daytime and nighttime VLF signal conditions. The improvement was achieved through case-by-case manual labeling, replacing random undersampling with SMOTE for training dataset

balancing, substituting the random forest model with the XGB model, expanding the feature list and employing a cluster correction after the classification process. The results are promising; however, additional refinement and improvement is necessary, which will be the focus of subsequent research.

Acknowledgement

VLF data are provided by the WALDO database (https://waldo.world, accessed on 1 January 2023), operated jointly by the Georgia Institute of Technology and the University of Colorado Denver, using data collected from those institutions as well as Stanford University, and has been supported by various US government grants from the NSF, NASA, and the Department of Defense.

References

Arnaut, F. & Kolarski, A., 2023. Machine learning approach for distinguishing daytime and nighttime ionospheric conditions on VLF signals related to solar flares during 2011. In XX Serbian Astronomical Conference, 16-20 October 2023, Belgrade, Serbia. Book of Abstracts, Astronomical Observatory of Belgrade and Faculty of Mathematics, pp. 79

Arnaut, F., Kolarski, A. and Srećković, V.A., 2023. Random forest classification and ionospheric response to solar flares: Analysis and validation. Universe, 9(10), p.436.

Arnaut, F., Kolarski, A. and Srećković, V.A., 2024. Machine Learning Classification Workflow and Datasets for Ionospheric VLF Data Exclusion. Data, 9(1), p.17.

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[Invited Lecture]

Analysis of flood fatalities in the Republic of Serbia

Milica Langović[1*]

[1] Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Serbia

[*]Correspondence: milica.langovic@ipb.ac.rs

Abstract: The paper analyses the impact of floods on the loss of human lives in the Republic of Serbia in the period 1960-2023. In the purpose of the paper, a dataset based on EM-DAT data on the number of floods and deaths caused by floods were analyzed in this period. It was shown that floods have not only socio-economic but also demographic consequences. Likewise, it has been established that floods occurred more frequently in Serbia at the beginning of the 21st century than in previous periods. Based on the available data, the floods in 1981 and 2014 were identified as the ones with the highest number of fatalities. In order to reduce effects of future floods on human life, the paper emphasized the importance of adequate policies.

Keywords: flood, fatalities, population, Serbia

Introduction

Natural disasters are destructive events of atmospheric, geological and hydrological origin, including floods, earthquakes, volcanic eruptions, landslides, tsunamis, droughts etc. Floods are the most frequent natural hazard event and have serious health, social and economic consequences (Liu et al., 2024).

The reported flood-related impacts on society and human health are widespread and complex. Floods continue to affect communities unequally and in different ways, with impacts ranging from short to longer term (Alderman et al., 2012). In recent decades, the number of people affected by floods and the number of deaths directly caused by them has increased (Yang et al., 2023). Flood mortality is a real problem worldwide and many countries are affected by the impacts at different levels. For every fatal flood, one or more people died due to a range of circumstances (Petrucci, 2021).

The impact of a flood is strongly influenced by the characteristics of the flooded area and the characteristics of the flood itself. For example, fast-rising flash floods can cause greater devastation than smaller floods due to drainage problems, and people in developing countries may be more vulnerable to the risk of flooding than people in developed regions. Area characteristics such as population density and size, land use, warning and emergency response vary at the regional level and have a major impact on the loss of life from flooding (Jonkman, 2003).

The floods in Serbia, which were accompanied by great material damage and loss of life, posed great challenges to society (Aćimović, 2021). This natural disaster is therefore increasingly being discussed in the media and in scientific circles. The main objective of this article is to provide an insight into the number of deaths caused by floods in Serbia and to analyse whether and how the impact of floods has changed over time.

Methods and data

For the purpose of this paper, EM-DAT data (https://www.emdat.be/) on the total number of deaths caused by floods in the Republic of Serbia were analysed. EM-DAT defines flood as "A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than- normal levels along the coast (coastal flooding) and in lakes or

reservoirs, as well as ponding of water at or near the point where the rain fell (flash floods)" (EM-DAT, 2024a). A dataset based on EM-DAT data on the number of deaths caused by floods, covering the period from 1960 to 2023.

Results and discussion

The data analysis shows that from 1960 to 2023, 28 floods were registered on the territory of Serbia, including mainly river floods. the number of floods at the beginning of the 21st century is significantly higher than in the previous period. From 1960 to 2001, five floods were recorded, while 23 floods were recorded from 2002 to 2023 (EM-DAT, 2024b).

Table 1. Total deaths caused by floods in the Republic of Serbia, 1960-2023.

year	Total deaths	year	Total deaths
1965	3	2013	-
1981	70	2013	-
1999	11	2014	-
1999	-	2014	51
2000	-	2014	1
2002	-	2014	4
2005	2	2016	-
2006	-	2016	-
2006	-	2018	-
2007	-	2019	-
2009	-	2020	-
2010	-	2021	-
2010	2	2023	2
2010	-	2023	-

Source: EM-DAT, 2024b.

Between 1960 and 2023, floods caused the deaths of 146 people. Based on the available data, the floods of 1981 and 2014 were singled out as the floods with the highest number of fatalities on the territory of the Republic of Serbia. In the 1999 floods, 11 people lost their lives. In other years, less than 10 people were affected by the floods. It is important to note that according to EM-DAT data, in most cases the impact of floods on human lives is unknown or unreported (Table 1).

In the 21st century, the floods in 2014 have had the greatest impact on the population in Serbia. After these floods, more attention was paid to this problem. Due to the socio-economic impact and the consequences for the population, some researchers have emphasised the importance of prevention, pointing out that investing in flood protection can lead to reducing the loss of life, i.e. avoiding a human tragedy. In addition to the humanitarian impact achieved by investing in protection against natural disasters, such an investment can also bring significant economic gains and cost savings for the state. The assessment of hazards and risks, accurate weather forecasts, the improvement of the early warning system and the timely announcement of extreme weather situations would be of great importance. In this context, the importance of local governments and capacity building is also emphasised. It is pointed out that local self-governments need permanently employed experts who specialise in a specific topic in order to minimise the impact of floods on the population (Ristić et al., 2017; Aćimović, 2021).

Conclusions

Floods are natural disasters that have different effects on the population in different parts of the world. Serbia is one of the countries where floods have catastrophic consequences for the population. According to the available data, 146 people died in Serbia in the period 1950-2023. Every life is important and the impact of future floods on people must be minimised. The researchers

suggest that policy makers should raise awareness of the increased risk to the population in order to improve disaster management strategies and thereby reduce the number of deaths (Yang et al., 2023). However, this issue in Serbia therefore requires more research that can serve as a framework for policy.

References

Aćimović, S. 2021. Sistem odgovora na krize u smanjenju ekonomske štete od poplava. *Ekonomija, teorija i praksa*, 14(1), 42-53.

Alderman, K., Turner, L. & Tong, S. 2012. Floods and hu-man health: a systematic review. *Environment International*, 47, pp. 37-47.

EM-DAT. 2024a. Hydrological Hazards. Available from https://doc.emdat.be/docs/data-structure-and-content/glossary/hydrological-hazards/

EM-DAT. 2024b. public_emdat_custom_request.

Jonkman, S.N. 2003. Loss of life caused by floods: an overview of mortality statistics for worldwide floods. Delft Cluster. Available from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=a034ddd98094abf782beb8b58dc1b29c90bf5e6e

Liu,Q., Du, M., Wang, Y., Deng, J., Yan, W., Qin, C., Liua, M. & Liu, J. 2024. Global, regional and national trends and impacts of natural floods, 1990–2022. *Bull World Health Organ*. 102, 410–420. http://dx.doi.org/10.2471/BLT.23.290243

Petrucci, O. 2021. Factors leading to the occurrence of flood fatalities: a systematic review of research papers published between 2010 and 2020. *CNR-IRPI Research Institute for Geo-Hydrological Protection*. Available from https://nhess.copernicus.org/preprints/nhess-2021-269/nhess-2021-269-manuscript-version3.pdf

Ristić, R., Polovina, S., Malušević, I. & Milčanović, V. 2017. Srbija i bujične poplave: tri godine posle katastrofe u maju 2014. godine. *Vodoprivreda, 49,* 245-252.

Yang, Z., Huang, W., McKenzie, J.E., Xu, R., Yu, P., Ye, T., Wen, B., Gasparrini, A., Armstrong, B., Tong, S., Lavigne, E., Madureira, J., Kyselý, J., Guo, Y. & Li, S. 2023. Mortality risks associated with floods in 761 communities worldwide: time series study. *BMJ*. 1-10. https://dx.doi.org/10.1136/bmj-2023-075081

[https://doi.org/10.69646/aob241205]
[Invited Lecture]

Annual PM2.5 and PM10 Variations on Belgrade's Mostar Interchange – Traffic Impact

Sreten Jevremović[1*], Milica Langović[1], Aleksandra Kolarski[1] and Filip Arnaut[1]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Republic of Serbia

[*]Correspondence: jevremovic749@gmail.com

Abstract: Air pollution is becoming an increasingly pronounced problem globally, while Belgrade is often one of the most polluted cities in Europe. Some of the most common emitters and air pollutants are individual combustion plants, factory plants and traffic. In this paper, the variations of PM2.5 and PM10 particles were analyzed in the four-year period (from 2018 to 2021) in the area of Mostar interchange in Belgrade. The results showed that there is a statistically significant difference in the levels of PM2.5 and PM10 particles by year, which is why the influence of traffic on the increase in the level of harmful substances in the air was analyzed. The analysis showed that traffic has no influence on the change of PM2.5 and PM10 particles at the analyzed location. The obtained results indicate that traffic, in this particular case, is not a central source of pollution, but of course it can have an impact on reducing air quality. Accordingly, the impacts of other emitters, such as individual combustion plants and factory plants, on the territory of Belgrade should be analyzed and determined in more detail, which will be the subject of future research.

Keywords: Air pollutants, air quality, PM2.5, PM10, traffic

[https://doi.org/10.69646/aob241206]
[Invited Lecture]

Space weather influence and multifaceted observations of natural hazards events inferred from sub-ionospheric VLF/LF electric fields and satellite magnetic measurements

Hans Eichelberger[1*], Aleksandra Nina[2], Mohammed Y. Boudjada[1], Aleksandra Kolarski[2], Nikola B. Veselinović[2], Giovanni Nico[3], Pier Francesco Biagi[4] and Vladimir A. Srećković[2]

[1]Space Research Institute, Austrian Academy of Sciences, Schmiedlstr. 6, 8042 Graz, Austria
[2]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia
[3]Institute of Applied Mathematics, Italian National Research Council, Via Giovanni Amendola
122/I, 70126 Bari, Italy
[4]Department of Physics, University of Bari, Via Amendola 173, 70125 Bari, Italy

[*]Correspondence: hue@oeaw.ac.at

Abstract: Monitoring of the ionosphere enables the detection of changes that are related to numerous processes on Earth. However, space weather, primarily solar radiation, has a very significant influence on the atmospheric layers. Variations caused by these influences can be affected by some processes on Earth, which can be used to detect relevant terrestrial processes. On the other hand, the strong influence of solar radiation can mask changes due to processes on Earth. Therefore, it is important to examine the impact of space weather on the detection of changes in signals associated with natural hazards. Natural hazards events like earthquakes or volcanic eruptions could significantly excite lithosphere – atmosphere

– ionosphere coupling (LAIC) up to high altitudes with different physical processes. However, the impacts of specific phenomena are complex and the details are still difficult to disentangle.

This study considers selected earthquakes (USGS catalogue) with magnitude M ≥5.5 related to LAIC coupling processes based on the combining of ground-based sub-ionospheric VLF/LF electric field measurements from the INFREP network and complementary low earth orbit (LEO) satellite magnetic field measurements. Ground-based and space borne observations require temporal and spatial proximity to the events.

We investigate electric field narrowband VLF/LF transmitter signals propagating in the ionospheric waveguide and detected by two INFREP receiving stations in Belgrade (Serbia) and Graz (Austria). It encloses areas along the radio paths from the lithosphere and up to the ionospheric D/E-layers. The analyses are carried out in the time- and frequency-domain and are restricted to European sites due to the INFREP network infrastructure. Complementary magnetic field measurements are obtained by ESA's three satellite Swarm mission at ~500 km altitude (ionospheric F-region). Case studies like the 29.12.2020 earthquake, M6.4, Petrinja, Croatia, and the 06.02.2023 Turkey-Syria earthquake sequence with M7.5 and M7.8 events, indicate a coupling via waves from the lithosphere and up to the LEO satellite orbits.

Statistically significant robust results, in both the VLF/LF electric field variations and satellite magnetic field measurements, are obtained for strong earthquakes. In order to observe these tricky interactions, one needs continuous VLF/LF measurements in a network structure and satellite-based resources as well as scientific cooperations.

Keywords: Natural hazards events, VLF/LF transmitter measurements, Swarm magnetic field observations, INFREP network

Acknowledgement

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[https://doi.org/10.69646/aob241207]
[Invited Lecture]

Electron-induced excitation and recombination of BeH^+ ions and isotopomers

Nicolina Pop[1*], Emerance Djuissi[2], Jeoffrey Bofelli[2], Janos Zsolt Mezei[3], Felix Iacob[4], Sebastien Niyonzima[5], Detlev Reiter[6], Kalyan Chakrabarti[7] and Ioan F. Schneider[2,8]

[1]Dept. of Fundamental Physics for Engineers, Politehnica University, Timisoara, 300006, Romania
[2]Laboratoire Ondes et Milieux Complexes, CNRS, Univ. Le Havre Normandie, Le Havre, 76058, France
[3]Inst. of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, H-4001, Hungary
[4]Physics Faculty, West University of Timișoara, Timișoara, 300223, Romania
[4]Département de Physique, Université du Burundi, Bujumbara, 1550, Burundi
[6]Institute for Laser and Plasma Physics, Heinrich-Heine-University, D-40225 Düsseldorf, Germany
[7]Department of Mathematics, Scottish Church College, Calcutta 700 006, India
[8]Laboratoire Aimé Cotton, CNRS, ENS Cachan and Univ. Paris-Sud, Orsay, 91405, France

Correspondence: nicolina.pop@upt.ro

Abstract: Cross sections and Maxwell rate coefficients for reactive collisons between electrons and Beryllium monohydride cations and isotopologues are computing using the Multichannel Quantum Defect Theory (MQDT). The key challenge in the use of beryllium as main chamber material for experimental and commercial fusion devices is to understand, predict and controle the characteristics of the thermonuclear burning plasma. Due to its toxicity, few experimental data are currently available. In order to model and

diagnose the low-temperature edge plasmas, a complete database for electron-impact collision processes is required for molecular species containing beryllium and hydrogen. Significant fractions of the eroded beryllium will be transported towards the divertor and will form compounds with the fuel atoms, molecules and/or molecular ions. For the fusion plasma edge, extensive cross sections and rate coefficients have been produced for BeH^+ (Niyonzima et al., 2017), BeD^+ (Niyonzima et al., 2018) and BeT^+ (Pop et. al., 2021) cations. The isotopic effects demonstrates the quasi-independence of the rate coefficients on the istopologue, if they are represented with respect to the vibrational energy of the target, at a given electron temperature.

New computations on extended energy/temperature range, up to 12 eV/30000 K, are ongoing.

Reference

N. Pop et al., Phys. Chem. Chem. Phys., ,26, 18311(2024).

N. Pop et. al., Atomic Data and Nuclear Data Table, 139, 101414 (2021).

S Niyonzima, N Pop, et.al., Plasma Sources Sci. Technol. 27, 025015 (2018).

S. Niyonzima, S. Ilie, N. Pop, et al., Atomic Data and Nuclear Data Table, 115-116, 287-308 (2017).

[https://doi.org/10.69646/aob241208]
[Invited Lecture]

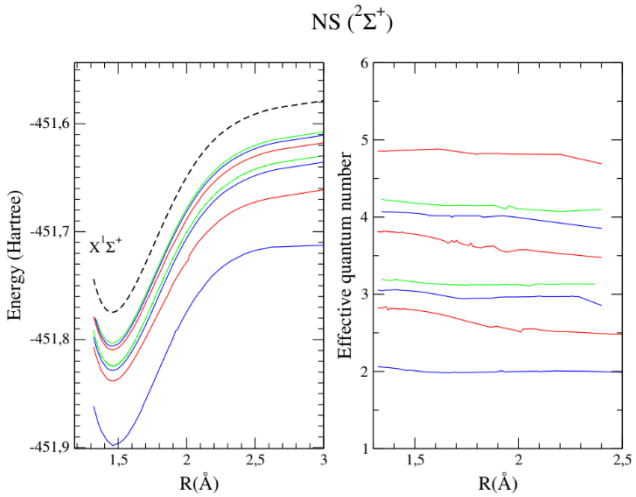
Molecular Electron Collisions in Exoplanet Atmospheres and the Interstellar Medium

Felix Iacob[1*]

[1]Physics Faculty, West University of Timisoara, 300223, Timisoara, Romania

*Correspondence: felix.iacob@gmail.com

Abstract: Recent changes in the climate have sparked interest in studying molecular-electron collisions in exoplanet atmospheres and, to a greater extent, in the interstellar medium. The competitive model of quantum mechanics can be used to describe Feshbach resonances, which are extremely excited bound states superposed with the continuum. Because they generate dissociation at low energy, these bound states are essential for explaining the dissociative recombination of the molecule that often occurs in this plasma environment. One effective theory that yields quantitative findings for identifying the interaction indicated by potential energy curves is the R-Matrix technique.
The contribution of Feshbach resonances to the dissociation of molecules, as indicated by the dissociative rates, will be discussed in this presentation. The illustrations are based on NS molecule.



Reference

F. Iacob et al 2022 J. Phys. B: At. Mol. Opt. Phys. 55 235202
J. Tennyson, Phys. Rep. 491, 29 (2010)
R Hassaine et al 2024 J. Phys. B: At. Mol. Opt. Phys. 57 165201

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[Invited Lecture]

Recent advances in the kinetic and fluid modeling of Resistive Plate Chambers

Saša Dujko[1*], Ilija B. Simonović[1] and Danko Bošnjaković[1]

[1]Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[*]Correspondence: sasa.dujko@ipb.ac.rs

Abstract: This work explores and describes new advances in fluid and kinetic modeling of resistive plate chambers (RPCs). RPCs are gaseous particle detectors often used for triggering and timing purposes in many high-energy physics experiments. At the Large Hadron Collider at CERN, all mega science experiments, ATLAS, CMS, ALICE, and LHCb, use RPCs in slightly different configurations, mainly for triggering muons and particle identification (Abbrescia et al. 2024). RPCs are also used for detecting charged particles in extensive air showers, which are cascades of secondary particles created when a high-energy cosmic ray interacts with the Earth's atmosphere (Abreu et al. 2018). RPC detectors are a vital component of the Iron Calorimeter detector at the India-based Neutrino Observatory (Kumar et al. 2017). They are used to detect muons produced by neutrino interactions with the iron plates in the Iron Calorimeter. RPCs can also be used for air quality monitoring by analyzing ionization caused by pollutants. They also found their way in novel medical imaging technology that combines RPC technology and Positron Emission Tomography (Fonte et al. 2023). In most of these experiments and applications, RPCs are operated with a gas mixture composed of $C_2H_2F_4$, iso-C_4H_{10}, and SF_6. Due to the very high global warming potentials of $C_2H_2F_4$ and SF_6, the search for a suitable replacement for $C_2H_2F_4$ and SF_6 is currently one of the major concerns in RPC technology. This work explores the possibility of using $C_3H_2F_4$ and

C_3HF_5 instead of $C_2H_2F_4$, as well as CF_3I, $C_5F_{10}O$, and C_4F_7N instead of SF_6. Using a swarm method of deriving cross sections, we have developed complete and consistent cross-section sets for electron scattering in these gases. Cross sections are then used as input to solve the Boltzmann equation. The hierarchy of kinetic equations resulting from a spherical harmonic decomposition of the Boltzmann equation in the hydrodynamic regime is solved numerically by expanding the moments of the distribution function in terms of Sonine polynomials about a variety of Maxwellian distributions at different temperatures (Dujko et al. 2010). Electron swarm transport coefficients and distribution functions are calculated under a wide range of conditions found in RPC detectors. Additionally, we calculate critical electric fields for both pure gases and RPC gas mixtures, which ultimately determine the minimal operating voltages of detectors. Special attention is paid to the explicit and implicit effects of electron attachment and ionization on the drift and diffusion of electrons. In the final stage of modelling, we apply the fluid equation-based model to study the inception and propagation of streamers in both standard RPC mixtures and new eco-friendly gas mixtures. Calculations and analysis are performed under LHC-like conditions. We use the first-order fluid model, which involves an advection-diffusion reaction equation for electrons, reaction equations for positive and negative ions, and assumes a local field approximation. Both axisymmetric and 3D settings are used to implement the model in the AMReX environment. AMReX is an open-source C++ library for massively parallel block-structured adaptive mesh refinement applications (Zhang et al. 2019). The system of partial differential equations is solved using its mathematical machinery, where one of the most critical parts is the accurate and efficient solving of the Poisson equation (Simonović et al. 2024). The inception and propagation of positive streamers are simulated by assuming a certain level of background ionization, as accurate models of photoionization for complex RPC gas mixtures are not yet available. Nevertheless, in 1.5-dimensional setup, we employ a simple model of

photoionization, in which the photon mean free path and the photoionization quantum efficiency are considered as effective values, averaged over the relevant photoemission bands (Bošnjaković et al. 2016). We calculate the electron density, densities of positive and negative ions, and electric field as a function of the externally applied electric field for both standard and new eco-friendly gas mixtures. Other streamer characteristics, like velocity and radius, are also calculated and discussed. It has been found that the streamer radius depends on the electric field and its uniformity, gas pressure, and streamer polarity.

Keywords: Resistive Plate Chambers, Electron transport, Streamers, Boltzmann equation, Classical fluid model, AMReX

Acknowledgement

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References

Abbrescia M., et al., 2024, Eur. Phys. J. C 84, 300.
Abreu P., et al., 2018, Eur. Phys. J. C 78, 333.
Bošnjaković D., Petrović Z.Lj., Dujko S., 2016, J. Phys. D: Appl. Phys. 49, 405201.
Dujko S., White R.D., Petrović Z.Lj., Robson R.E., 2010, Phys. Rev. E. 81, 046403.
Fonte P., et al., 2023, Nucl. Instrum. Meth. A 1051, 168236.
Kumar A., et al., 2017, Pramana-J. Phys. 88, 79.
Simonović I., Bošnjaković D., Teunissen J., Dujko S., 2024, Plasma Sources Sci. Technol. 33, 085012.
Zhang W., et al., 2019, J. Open Source Softw. 4, 1370.

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[Invited Lecture]

Application of Stark broadening in astrophysics and space sciences

Magdalena D. Christova[1*]

[1]Department of Applied Physics, TU Sofia, Bulgaria

*Correspondence: mchristo@tu-sofia.bg

Abstract: We will present a part of our recent calculated results for Stark broadening parameters of spectral lines. Semiclassical perturbation theory in collisional approach of Sahal-Bréchot and developed further is used. Plasma conditions of interest cover a wide range of temperatures and particle densities, and they are applicable for the interpretation and analysis of stellar spectra. A demonstration of Stark broadening influence on the spectral lines in stellar spectra will be given.

Lectures

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[Lectures]

Fluence of energetic protons at L1 in heliosphere before and during some extreme space weather events in heliosphere

Nikola B. Veselinović[1*], Mihailo R. Savić[1], Darije Maričić[2], Filip Šterc[2], Dejan R. Joković[1], Radomir M. Banjanac[1] and Aleksandar L. Dragić [1]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia
[2]Astronomical Observatory Zagreb, Opatička 22, 10000 Zagreb, Croatia

[*]Correspondence: veselinovic@ipb.ac.rs

Abstract: The study of transient phenomena caused by solar activity is of great importance (Savić et al. 2023), as these events can affect Earth's magnetosphere, environment, technological infrastructure, and systems (see Kataoka et al. 2018, Belov et al. 2022, Kolarski et al. 2023, and references therein). Extreme events originating from the Sun, in addition to inducing various processes in the heliosphere such as shock waves and particle acceleration (Waterfall et al. 2023), can increase the flux of charged particles within the heliosphere.
In this work, the relationship between various solar activity indices and event-integrated fluence spectra of energetic protons measured at Lagrange Point L1 has been studied. The investigation focuses on the parametrization of differential fluence spectra using several proposed models to characterize the fluence spectra before and during extreme events. Three functions used to model the energetic proton fluence spectra appear to be comparatively useful in this type of analysis. This study demonstrates that SEP enhancement at L1 concurrent with the arrival of the CME shock is well-modeled by modified power-law functions. However, structures that do not coincide with the shock arrival (and often precede it) are poorly

modeled, leading to the conclusion that these particles are apparently not related to the shock and possibly have a different origin.

Keywords: Solar energetic particles, solar activity, fluence spectra

References

Belov, A., Shlyk, N., Abunina, M., Belova, E., Abunin, A., Papaioannou, A. (2022), Universe, 8, 403.

Kataoka, R., Sato, T., Miyake, S., Shiota, D., Kubo, Y. (2018), Space Weather, 16, 917–923.

Kolarski, A., Veselinović, N., Srećković, V.A., Mijić, Z., Savić, M,; Dragić, A. (2023), Remote Sens., 15, 1403

Savić, M., Veselinović, N., Dragić, A., Maletić, D., Joković, D., Udovičić, V., Banjanac, R., Knežević, D. (2023), Advances in Space Research, 71, 4, 2006-2016

Waterfall, C. O. G., Dalla, S.; Raukunen, O., Heynderickx, D., Jiggens, P., Vainio, R. (2023), Space Weather, 21.

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[Lectures]

Aerosol vertical profiles and ABL heights derived from lidar measurements in Belgrade

Maja Kuzmanoski[1*] and Zoran Mijić[1]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[*]Correspondence: maja.kuzmanoski@ipb.ac.rs

Abstract: Information on vertical profile of atmospheric aerosols is important in studies of aerosol contribution to air pollution, their role in cloud formation and radiative effects. Aerosol lidar measurements provide information on vertical profiles of aerosol backscatter and extinction coefficients. Besides, it can be used to derive the height of atmospheric boundary layer (ABL), which determines the volume available for dispersion of air pollution. Aerosol lidar measurements at 355 nm performed in Belgrade (Mijić et al., 2023) are used to derive vertical profile of aerosol backscatter coefficient and temporal changes of ABL height (Ilić et al. 2018). These measurements are used to determine the altitude of long-range transported aerosols (such as Saharan dust) and to detect their intrusion into the ABL. Selected cases of lidar-derived aerosol backscatter coefficient profiles corresponding to episodes of elevated air pollution, as well as episodes of long-range aerosol transport and their intrusion into the ABL, will be presented. Air pollution measurements in Belgrade, obtained from the Serbian Environmental Protection Agency (SEPA) automatic monitoring stations are used to select times of high and low particulate air pollution and to analyze the contribution of long-range transported aerosol to PM10 concentrations at surface level.

Keywords: aerosol lidar, atmospheric boundary layer, aerosol backscatter coefficient, air pollution

References

Ilić, L., Kuzmanoski, M., Kolarž, P., Nina, A., Srećković, V., Mijić, Z., Bajčetić, J. & Andrić, M.. (2018). Changes of atmospheric properties over Belgrade, observed using remote sensing and in situ methods during the partial solar eclipse of 20 March 2015, *Journal of Atmospheric and Solar-Terrestrial Physics*, 171, 250-259. https://doi.org/10.1016/j.jastp.2017.10.001

Mijić, Z., Ilić, L. and Kuzmanoski, M. (2023) Data quality assurance for atmospheric probing and modeling: characterization of Belgrade Raman lidar station, *Contributions of the Astronomical Observatory Skalnaté Pleso*, 53(3) 163-175, https://doi.org/10.31577/caosp.2023.53.3.163.

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[Lecture]

Impacts of seismic activity on human mobility

Milica Langović[1*], Vladimir A. Srećković[1], Aleksandra Kolarski[1], Filip Arnaut[1] and Sreten Jevremović[1]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Republic of Serbia

[*]Correspondence: milica.langovic@ipb.ac.rs

Abstract: Earthquakes are natural disasters that have led to the displacement of large number of people in different parts of the world. These geophysical events, often destructive in scale, lead to short- or long-term displacement from vulnerable areas. The aim of this research is to analyse the impact of earthquakes on the intensity and dynamics of human mobility in the Balkan region. For this purpose, data on internal displacement under the influence of earthquakes in the Balkan countries in the period 2008-2023 were analysed and processed. The results show that the earthquake is a serious push factor for human mobility and has a major influence on the decision of the population in the Balkans to migrate. It was found that the largest number of internal displacements under the influence of earthquakes was recorded in Croatia and Albania. However, it is important to point out that the intensity of displacement is directly related to the magnitude of the earthquake and the resulting living conditions and environmental damage. In order to provide a detailed overview of the different aspects of this topic, this paper emphasises the need for more detailed research on this topic in the area mentioned.

Keywords: human mobility, earthquakes, Balkan countries

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[Lecture]

Overview of Serbian involvement in COST framework – new open call and networking tools for young researchers and ITC participants

Zoran Mijić[1*] and Bratislav P. Marinković[1]

[1]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[*]Correspondence: zoran.mijic@ipb.ac.rs

Abstract: Serbia is COST (European Cooperation in Science and Technology) full member country and during the last decade there is an increasing interest of researchers and innovators from Serbia to actively participate in COST networking activities. In this paper the statistical overview of Serbian participants will be presented based on the available data for 2023. There is an increasing trend in country representation in active COST actions reaching 97% in 2023, and almost double leadership positions in actions comparing to 2018. Taking into the account activity, actions Management Committee (MC) members from Serbia have the leading role and mobilization of young researchers is among top five countries. Having in mind MC members are nominated by COST national coordinator following specific national procedure (Mijić and Marinković, 2024) these statistical indicators are useful to assess the quality of the current national rules and its possible improvements. New open call OC-2025-1 have been lunched and introduced young researchers and ITC (Inclusive Target Country) conference grants (Mijić and Marinković, 2024a) which will be discussed together with additional networking opportunities.

Keywords: COST, research network, young researchers, actions networking tools

References

Mijić, Z., Marinković, B. 2024. Participation of Serbian Researchers in COST Activities and an Overview of COST Procedures and National Rules for Joining Recently approved COST, *VI Conference on Active Galactic Nuclei and Gravitational Lensing*, 34-35, Zlatibor, Serbia, 2-6 June, 2024.

Mijić, Z., Marinković, B. 2024a. New opportunities for COST participants – actions networking tools and examples of the national funding schemes, *International Meeting on Data for Atomic and Molecular Processes in Plasmas: Advances in Standards and Modelling*, 49-50, Palić, Serbia, November 12-15, 2024.

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[Lecture]

Non-typical Spectral Line Shapes from Laboratory Plasma of Interest for Astrophysics

Nikola Cvetanović[1*] and Bratislav M. Obradović[2]

[1]University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade, Serbia
[2] University of Belgrade, Faculty of Physics, Belgrade, Serbia

[*]Correspondence: nikola@ff.bg.ac.rs

Abstract: Spectral line shapes are a powerful diagnostic tool for investigating both laboratory and astrophysical plasma. Typical applications include determination of plasma parameters and the strength of the electric or magnetic field. However, in certain cases atypical line shapes occur that cannot be explained using standard models for the line-profile analysis e.g. Doppler or pressure line broadening. To perform the line analysis in such cases, new and advanced fitting procedures must be developed, often paired with imaging and backed up by wider theoretical framework to take in to account the specific processes at play. The physical mechanisms that cause such line-shape effects in laboratory plasma are often similar or analogous to those in astrophysical plasma. Therefore, the methods can be seen as a link between the laboratory plasma formed in controlled experiments and the investigation of astrophysical objects.

Keywords: plasma, spectral line shape, experiment

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[Lecture]

Quantum calculation of the optical properties of dense plasma

Nenad M. Sakan[1*], Zoran Simić[2], Vladimir A. Srećković[1] and Momchil Dechev[3]

[1]University of Belgrade, Institute of Physics Belgrade, PO Box 57, 11001 Belgrade, Serbia
[2]Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
[3]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, 72, Tsarigradsko chaussee Blvd. Sofia, Bulgaria

[*]Correspondence: nsakan@ipb.ac.rs

Abstract:
A problem of describing a optical properties of dense plasma arises from the inconsistency of the application of the models for plasma of moderate or extreme densities onto high density plasma. Although it is not of extreme interest in laser confined fusion, the interest of plasma of moderate and high density is of high importance in Solar and stellar plasma, especially in photosphere region. From the reason of applicability, the steps for inclusion of complex ions are made. Since the moderate density plasma models are not capable to describe a strong collective phenomena in dense plasma, and since commonly used molecular dynamic coupled with Schrodinger solver is computing power hungry and in case of moderate density plasma they must use a much bigger ansamble of particles with enlarged calculation error. Here a retrospective of approach in fully quantum model is presented. The relatively simple model is capable of describing a emitter in dense plasma. Here the focus would be both on model potential as well as ideas for further development of used model. The further steps could bring a more accurate and widely

applicable model that could help in research of both theoretical as well as experimental research of dense plasma.

Keywords: dense plasma, optical properties, Schrodinger equation, model potential

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[Lecture]

Experimental and theoretical investigation of electron interaction with molecules

Jelena B. Maljković [1] Jelena Vukalović[1,2], Francisco Blanco[3], Gustavo García[4] and Bratislav P. Marinković[1]

[1] Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia
[2] Faculty of Science, University of Banja Luka, Mladena Stojanovića 2, 78000 Banja Luka, Republic of Srpska, Bosnia and Herzegovina
[3] Departamento de Física Atómica Molecular y Nuclear, Facultad de Ciencias Físicas, Universidad Complutense, Avda. Complutense s/n, E-28040 Madrid, Spain
[4] Instituto de Matemáticas y Física Fundamental, Consejo Superior de Investigaciones Científicas, Serrano 121, 28006 Madrid, Spain

Correspondence: jelenam@ipb.c.rs

Abstract: In response to escalating concerns regarding the environmental implications of anesthetic compounds on both global warming and ozone layer degradation, a rigorous investigation combining theoretical and experimental methodologies was conducted to elucidate the elastic electron scattering dynamics of halothane, sevoflurane, and isoflurane. These anesthetic gases, which are predominantly excreted into the atmosphere without degradation post-use, contribute to increasing concentrations of halogenated compounds that possess both elevated Global Warming Potentials (GWP) and significant Ozone Depletion Potentials (ODP). Our experimental methodology involved measuring elastic differential cross sections (DCS) using a crossed-beam apparatus, relative-flow method, with argon as a standard, to calibrate the absolute scale of the cross sections. Theoretical analyses were further executed

through the Independent Atom Model coupled with the Screening Corrected Additivity Rule (IAM-SCAR+I), accounting for interference effects.

Introduction

Halogenated anaesthetics, including sevoflurane ($C_4H_3F_7O$) (Vukalović et al., 2022a), isoflurane ($C_3H_2ClF_5O$) (Vukalović et al., 2024) and halothane ($C_2HBrClF_3$) (Maljković et al., 2023), are widely used in clinical settings for inhalational anaesthesia due to their effective anaesthetic properties (Robinson and Toledo, 2012). These compounds, however, are released into the atmosphere largely unchanged (Shiraishi and Ikeda, 1990; Gadani and Vyas, 2011), raising environmental concerns due to their significant global warming potential (GWP) and varying impacts on ozone depletion [Brown et al., 1989; Langbein et al., 1999; Sulbaek et al., 2012; Ryan and Nielsen, 2010). The molecular structures and halogen content play crucial roles in determining their atmospheric behaviour and interaction with other chemical species. Sevoflurane (Vukalović et al., 2022a), characterized by a relatively high molar mass and a dipole moment of 2.33 D, is preferred for its rapid induction and recovery and lower environmental impact compared to other halogenated anaesthetics. Isoflurane (Vukalović et al., 2024), with a molar mass of 184.5 g/mol and dipole moment of 2.47 D, exhibits moderate onset and recovery times. Halothane (Maljković et al., 2023), synthesized in 1954, has the highest ozone depletion potential among these anaesthetics due to its bromine content and a substantial GWP. Research into the electron scattering behaviour of these molecules is crucial for understanding their atmospheric lifetimes and reactivity. Elastic electron scattering cross sections provide insights into the physical interactions and potential fragmentation processes. This study presents experimental and theoretical cross sections for elastic

electron scattering from these three anaesthetics at 100 eV, contributing to the broader understanding of their environmental effects.

Methods and data

To derive differential and integral elastic scattering cross sections for the anesthetic molecules under study, the IAM-SCAR+I method was employed. This sophisticated approach synthesizes the Independent Atom Model (IAM) with the Screening Corrected Additivity Rule (SCAR) and incorporates interference effects (I). Detailed descriptions of this methodology are available in previous literature (Blanco et al., 2010; Fuss et al., 2013; Blanco et al., 2016; Traore Dubuis et al., 2017; Lozano et al., 2018); thus, only a concise summary is presented herein. Each molecular target, including sevoflurane ($C_4H_3F_7O$), isoflurane ($C_3H_2ClF_5O$), and halothane ($C_2HBrClF_3$), is represented as an ensemble of constituent atoms (C, H, F, O, Cl, and Br). For each atomic unit, an "ab initio" optical potential was derived as $(r) = VR(r) + iVabs(r)$, where the imaginary component accounts for inelastic processes, while the real component describes elastic scattering events. Molecular scattering cross sections were calculated by summing individual atomic amplitudes with phase corrections applied through SCAR, accommodating interference effects. For molecules with substantial dipole moments, such as isoflurane (2.47 D), rotational excitation effects were incorporated using the first-Born approximation, under the assumption of rigid rotor behavior. Corrections for large-angle scattering, based on Dickinson's approach (for details see (Sanz et al., 2012)) were applied to ensure rigorous representation of the scattering dynamics. Considering the experiment, elastic electron scattering measurements were conducted using a high-precision spectrometer, composed of an electron gun, gas inlet, energy analyzer, and detector, enclosed within a chamber shielded by two concentric μ-metal layers to minimize external magnetic interference

(Vukalović et al., 2022b). The electron gun directed a beam into the interaction region at an energy of 100 eV, achieved through careful adjustment of the potential difference between the filament and a grounded electrode. Anaesthetic gases (isoflurane, sevoflurane, and halothane) were introduced into the chamber via a gas needle connected to a handling system, raising the chamber's base pressure from $6 \cdot 10^{-7}$ mbar by approximately one order of magnitude. After gas-molecule interaction, scattered electrons were channeled into a two-stage cylindrical energy analyzer, allowing passage of elastically scattered electrons based on precisely calibrated potential differences. These electrons were subsequently focused by a three-electrode lens into a channeltron detector to measure scattering intensity. Measurements were recorded across a 25°–125° angular range with an energy resolution exceeding ±2°. Relative DCSs were normalized via the relative flow method (Srivastava et al., 1975), using argon as the reference. Absolute DCS values were determined through comparative measurement of electron intensities and flow rates for both the target gas and argon (Williams and Willis, 1975; Ranković et al., 2018) adjusting the gas flow behind the needle to achieve equivalent mean free paths (Olander and Kruger, 1970). This measurement cycle was repeated to ensure data consistency, with uncertainty assessments accounting for statistical variance, apparatus stability, and reference cross-section accuracy. The primary source of uncertainty (~20%) was associated with argon reference cross sections, particularly at small angles, where uncertainties were compounded by adjustments to the interaction volume.

Results and discussion

Absolute differential cross sections (DCSs) for elastic electron scattering from the anesthetic molecules halothane, isoflurane, and sevoflurane were measured and presented Figure 1. as a function of scattering angle. These measurements were conducted at an incident electron energy of 100 eV over an angular range of 25° to 125°, with

5-degree increments, except for halothane, where the range was 20° to 110°. All three anesthetic molecules exhibit a similar angular trend in their DCSs. The values decrease from small angles to approximately 60°–90°, reach a minimum, and then show a increase towards higher angles (approaching 180°). This behavior, characterized by a pronounced forward peak and a broad dip, is typical of molecular targets, as noted in previous studies (Maljković et al., 2019; Vukalović et al., 2022c). It is important to note that our experimental setup did not differentiate between elastic scattering and rotational excitations, and thus, the experimental DCSs represent quasi-elastic cross sections. The experimental data were normalized using the relative flow method, with argon as the reference gas (Williams and Willis, 1975; Ranković et al., 2018). Two absolute DCS points (three for halothane) were obtained and used to normalize the relative differential cross sections. These normalized points align well with the experimental data demonstrating the reliability of our normalization procedure. In summary, the experimental and theoretical DCSs show strong agreement for all three anesthetic molecules, contributing valuable insights into their scattering behavior and atmospheric interactions. These results are crucial for understanding the broader implications of halogenated anesthetics in environmental and physical chemistry contexts.

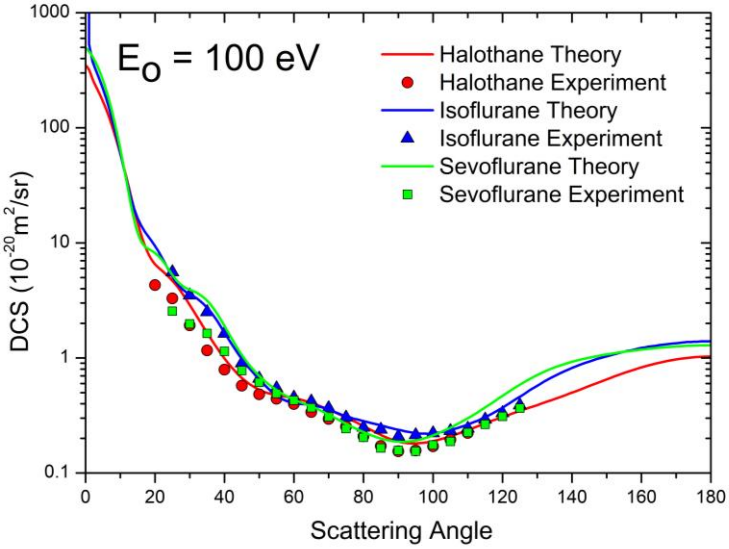

Figure 1. This graph presents the differential cross sections (DCS) for elastic electron scattering from halothane, isoflurane and sevoflurane at an incident electron energy of 100 eV, plotted together for a direct comparison.

Conclusion

This investigation provides a comprehensive analysis of elastic electron scattering from three halogenated anesthetic molecules: halothane, isoflurane, and sevoflurane at 100 eV. Differential cross sections (DCSs) were measured across an angular range of 25°–125°,for halothane, 20°–110°, using the relative flow method with argon as the reference gas to achieve absolute scaling. The resultant experimental data were normalized to absolute values, displaying strong alignment between normalized relative DCSs and absolute reference points, thus confirming the robustness of the experimental approach. Theoretical DCSs were computed using the IAM-SCAR+I method, which integrates the Independent Atom Model with the Screening Corrected Additivity Rule while incorporating interference

effects, yielding a high degree of congruence with experimental observations. These findings advance the understanding of the scattering dynamics of halogenated anesthetics, providing valuable insights into their atmospheric lifetimes and reactivity. By presenting novel DCS data alongside theoretical modeling, this work lays the groundwork for future investigations into the environmental impacts of anesthetic emissions, particularly regarding their contributions to global warming and ozone layer depletion.

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References

Blanco F, Ellis-Gibbings L, García G 2016 *Chem. Phys. Lett.* 645 71–75.

Blanco F, Rosado J, Illana A, García G 2010 *Phys. Lett. A* 374 4420–4424.

Brown A C, Canosa-Mas C E, Parr A D, Pierce J M T, Wayne R P 1989 *Nature* 341 635–637.

Fuss M C, Sanz A G, Blanco F, Oller J C, Limão Vieira P, Brunger M J, García G 2013 *Phys. Rev. A* 88 042702.

Gadani H, Vyas A 2011 *Anesth. Essays Res.* 5 5–10.

Langbein T, Sonntag H, Trapp D, Hoffmann A, Malms W, Röth E P, Mörs V, Zellner R 1999 *Br. J. Anaesth.* 82 66–73.

Lozano A, da Silva F F, Blanco F, Limão-Vieira P, García G 2018 *Chem. Phys. Lett.* 706 533–537.

Maljković J B, Vukalović J, Pesić Z D, Blanco F, García G, Marinković B P 2023 *Eur. Phys. J. Plus* 138 1–8.

Maljkovic J B, Vukovic J, Tökési K, Predojevic B, Marinkovic B P 2019 *Eur. Phys. J. D* 73 27.

Olander D R, Kruger V 1970 *J. Appl. Phys.* 41 2769.

Rankovic M L, Maljkovic J B, Tökési K, Marinkovic B P 2018 *Eur. Phys. J. D* 72 1–9.

Robinson D H, Toledo A H 2012 *J. Invest. Surg.* 25 141–149.

Ryan S M, Nielsen C J 2010 Anesth. Analg. 111 92–98

Sanz A G, Fuss M C, Blanco F, Sebastianelli F, Gianturco F A, García G 2012 *J. Chem. Phys.* 137 124103.

Shiraishi Y, Ikeda K 1990 *J. Clin. Anesth.* 2 381–386.

Srivastava S K, Chutjian A, Trajmar S 1975 *J. Chem. Phys.* 63 2659.

Sulbaek Andersen M P, Nielsen O J, Karpichev B, Wallington T J, Sander S P 2012 *J. Phys. Chem. A* 116 5806–5820.

Traoré Dubuis A, Verkhovtsev A, Ellis-Gibbings L, Krupa K, Blanco F, Jones D B, Brunger M J, García G 2017 *J. Chem. Phys.* 147 054301.

Vukalović J, Maljković J B, Blanco F, García G, Predojević B, Marinković B P 2022a *Int. J. Mol. Sci.* 23 21.

Vukalović J, Maljković J B, Tökési K, Predojević B, Marinković B P 2022b *J. Phys.: Conf. Ser.* 2415 012006.

Vukalovic J, Maljkovic J B, Blanco F, García G, Predojevic B, Marinkovic B P 2022c *Int. J. Mol. Sci.* 23 1–11.

Vukalović J, Marinković B P, Rosado J, Blanco F, García G, Maljković J B 2024 *Phys. Chem. Chem. Phys.* 26 985–991.

Williams J F, Willis B A 1975 *J. Phys. B: At. Mol. Phys.* 8 1670.

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[Lecture]

ASTROPHYSICALLY IMPORTANT MOLECULAR IONS: A NEW DATA FOR MODELING

Veljko Vujčić[1*], Vladimir A. Srećković[2*], Radoslav Zamanov[3] and Sanja Tošić[2]

[1]Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
[2]Institute of Physics Belgrade, Pregrevica 118, 11080, Belgrade, Serbia
[3]Institute of Astronomy, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria

[*]Correspondence: veljko@aob.rs, vlada@ipb.ac.rs

Abstract: Diagnostics, the development of models and simulations of intricate physical processes, and the interpretation of data from measurements all depend more and more on atomic and molecular (A&M) datasets, databases, and broader data environments (see e.g. Albert et al. 2020, Srećković et al. 2020). Precise spectroscopy of molecular ions pave the way for the investigation of tiny molecules such as SiH+, CaH+, and others that may be present astrophysically, which can in turn lead to better understanding of some stellar processes and formation of interstellar medium. We studied photodissociative processes involving calcium monohydride ions and gathered a cross-section dataset for simulating the aforementioned environments with various parameters (Vujčić et al. 2023). We studied calcium monohydride ion optical (photodissociative) processes and gathered cross-sectional data for the range of parameters that encompass modeling of the aforementioned environments.

Keywords: a&m data, astrochemistry, interstellar processes

Acknowledgement

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References

Albert, D., et al..: 2020, Atoms, 8(4), 76.
Srećković, V.A., et al.: 2020, Molecules 26.1, 151.
Vujčić, V. et al.: 2023, Phys. Chem. Chem. Phys., 25(40), 26972

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[Lecture]

Preliminary Analysis of Barometric and Temperature Effects in Cosmic Muon Datasets Simulated Using CORSIKA

Mihailo R. Savić[1*], Nikola B. Veselinović[1], Aleksandar L. Dragić[1], Dimitrije M. Maletić[1], Dejan R. Joković[1], Radomir M. Banjanac[1], David Knežević[1], Miloš Travar[1] and Vladimir I. Udovičić[1]

[1]Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[*]Correspondence: msavic@ipb.ac.rs

Abstract: Muon detectors are among the most widely used ground-based cosmic ray detectors, alongside neutron monitors. Due to the fact they detect higher energy primary cosmic rays, they serve as a complement to neutron monitors for long-term monitoring of cosmic ray variations and the study of space weather phenomena. Furthermore, alongside the existing independent detector setups and established networks, new muon detector networks are currently being developed and implemented.

Secondary cosmic ray muons are sensitive to changes in atmospheric conditions, particularly variations in atmospheric pressure and temperature. Careful study of these effects offers a twofold benefit: first, it allows better understanding of the fundamental processes affecting muon propagation through the atmosphere; second, it allows the correction of atmospheric effects, thus increasing the sensitivity of muon detectors to variations of primary cosmic rays.

Empirical models based on principal component analysis and machine learning have the benefit of taking into account the maximum information about the meteorological parameters. However, these are based on the assumption that all variations in muon count rates can be solely attributed to the change of

atmospheric parameters, and therefore introduce an inherent risk of overcorrection.

To minimize this potential drawback, models can be trained and tested on datasets that exclusively reflect variations in atmospheric parameters. One way to produce such data is by using the CORSIKA package, which can simulate extensive atmospheric showers while incorporating changing atmospheric conditions. Here, we present an analysis of preliminary data generated through this approach to establish how effectively CORSIKA simulates atmospheric effects on cosmic ray muons.

Keywords: Cosmic rays, Extensive Air Showers, Atmospheric Effects, Monte Carlo Simulations, CORSIKA

Posters

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[Poster]

The confined molecular systems and astrophysical models

Vladimir A. Srećković[1*], Veljko Vujčić[2], Milan S. Dimitrijević[2], Nicolina Pop[3], Felix Iacob[4], Nikolai Bezuglov[5,6], Zlatko Majlinger[7] and Magdalena D. Christova[8]

[1]Institute of Physics Belgrade, UB, 57, 11001, Belgrade, Serbia
vlada@ipb.ac.rs
[2]Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
veljko@aob.rs
[3]Politehnica University of Timisoara, Timisoara, Romania
nicolina.pop@upt.ro
[4]West University of Timișoara, Vasile Părvan Boulevard, 300233, Romania
[5]Institute of Atomic Physics and Spectroscopy, University of Latvia, Riga, Latvia
[6]Saint Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034, Russia
[7]University of Zagreb, Faculty of Science (PMF), Croatia.
[8]Department of Applied Physics, TU Sofia, Bulgaria; mchristo@tu-sofia.bg

[*]Correspondence: vlada@ipb.ac.rs

Abstract: The importance of computational chemistry techniques for examining the dynamics and interactions of molecules enclosed in larger structures has increased over the last few decades (Srećković et al. 2020, Albert et al. 2020). Despite their vast scale, molecular clouds play an important but little understood role in confined systems (Reis et al. 2022). There are currently a few hundred molecular species known to exist in interstellar space, ranging from diatomic to massive anions, cations, and neutrals (see, e.g. de Lara-Castells and Hauser 2020, Roesky & Mandel 2010). Interstellar radiation is scattered and absorbed into molecular clouds and molecules can resist

photodissociation and/or photoionization (Vujčić et al. 2023). Therefore, it is essential to investigate both radiative and collisional mechanisms.

Keywords: A&M data, Molecular ions, Molecular clouds, Confined systems

Acknowledgement

Through a grant from the Republic of Serbia's Ministry of Science, Technological Development, and Innovations, the Institute of Physics Belgrade, University of Belgrade, provided funding for this study. We acknowledged The Science Fund of the Republic of Serbia, Grant No. 3108/2021—NOVA2LIBS4fusion, COST Action CA21101, and the COST-supported project Confined Molecular Systems: from a New Generation of Materials to the Stars (COSY).

References

Albert, D., et al..: 2020, Atoms, 8(4), 76.
De Lara-Castells, M. P., and Hauser, A. W.: 2020, Phys. Life Rev. 32.
Mandal, S. K., and Herbert W. Roesky: 2010, Chemical communications, 46.33 6016.
Reis H., et al.: 2022 Frontiers in Chemistry 10, 941269.
Srećković, V.A., et al.: 2020, Molecules 26.1, 151.
Vujčić, V. et al.: 2023, Phys. Chem. Chem. Phys., 25(40), 26972.

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[Poster]

Novel Research in Astronomy & Earth Observation

Vladimir A. Srećković[1*], Zoran Mijić[1], Aleksandra Kolarski[1], Milica Langović[1], Filip Arnaut[1], Sreten Jevremović[2], Jelena Barović[3], Ognyan Kounchev[4] and Georgi Simeonov[4]

[1]Institute of Physics Belgrade, UB, 57, 11001, Belgrade, Serbia
[2] Scientific Society "Isaac Newton", Volgina 7, 11160 Belgrade, Serbia
[3] University of Montenegro, Podgorica, Montenegro
[4] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria

[*]Correspondence: vlada@ipb.ac.rs

Abstract: With a high potential for direct application in Earth and other planetary research, the innovative approach of the past few decades has promoted cooperation and productive synergies among disciplines like space exploration, atmospheric and Earth observations, laboratory and field experiments, and numerical modeling. To model atmospheres with supercomputers and diagnose astrophysical and laboratory plasma using atomic and molecular datasets, theoretical methodologies and data computation methods must be developed and improved (see e.g. Srećković et al., 2024 and references therein). To address complex climate issues and their consequences, multi-instrumental and multi-disciplinary expertise is required. As data grows, automated tools and retrieval approaches are increasingly being used (e.g., Škoda and Adam 2020). We participated in this research with our contribution.

Keywords: AstroGeoInformatics, modeling, climate, multi-disciplinary investigation

Acknowledgement

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References

Srećković, V.A.; Dimitrijević, M.S.; Mijić, Z.R. Data in Astrophysics and Geophysics: Novel Research and Applications. Data 2024, 9, 32

Škoda, P.; Adam, F. Knowledge Discovery in Big Data from Astronomy and Earth Observation; Elsevier: Amsterdam, The Netherlands, 2020

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[Poster]

Low ionosphere modeling: new dataset

Vladimir A. Srećković[1*]

[1]Institute of Physics Belgrade, UB, 57, 11001, Belgrade, Serbia

[*]Correspondence: vlada@ipb.ac.rs

Abstract: Severe solar radiation and activity can lead to a number of natural disasters, disrupt space communications and electrical equipment on Earth, and produce sudden ionospheric disturbances (SIDs) (see Srećković et al. 2021; Šulić et al. 2016). This work focuses on the analysis of ionosphere plasmas and their properties, as well as the investigation of SIDs utilizing very low frequency (VLF) radio signals to forecast the impact of strong radiation on Earth. We present dataset of ionosphere plasma parameters.

Keywords: data, modeling, climate, VLF

Acknowledgement

This work was funded by the Institute of Physics Belgrade, University of Belgrade, through a grant by the Ministry of Science, Technological Development, and Innovations of the Republic of Serbia. We acknowledge the support COST Action CA22162 A transdisciplinary network to bridge climate science and impacts on society (FutureMed), supported by COST.

References

Srećković, V. A., Šulić, D. M., Ignjatović, L., & Vujčić, V. (2021). Low Ionosphere under Influence of Strong Solar Radiation: Diagnostics and Modeling. Applied Sciences, 11(16), 7194.

Šulić, D. M., Srećković, V. A., & Mihajlov, A. A. (2016). A study of VLF signals variations associated with the changes of ionization level in the D-region in consequence of solar conditions. Advances in Space Research, 57(4), 1029-1043.

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[Poster]

Innovative UAV Approaches for Monitoring Riverbank Erosion and Lateral Channel Migration Processes

Marko Langović[1*] and Slavoljub Dragićević[1]

[1] University of Belgrade, Faculty of Geography, Serbia

*Correspondence: marko.langovic@gef.bg.ac.rs

Abstract: Modern physical-geographical research encompasses a comprehensive examination of the intensity and dynamics of natural processes, among which the processes of riverbank erosion and lateral channel migration stand out as particularly significant. The use of modern technologies (remote sensing, unmanned aerial vehicles and GIS software) provides new possibilities for fluvial geomorphology research, particularly with regard to accuracy, detail and visual representation. The aim of this article is therefore to point out the importance of the use of innovative UAV technology in the investigation of riverbank erosion process on the examples of the Kolubara and South Morava rivers in Serbia. The obtained results could be valuable for river channel management, water management, spatial end environmental planners and policy makers, etc.

Keywords: Riverbank erosion, UAV, drones, Lateral channel migration

Introduction

Riverbank erosion represents a component of lateral channel migration and is therefore recognised as a constant, active and most important geomorphological process in floodplains (Menting & Meijles, 2019; Sylvester et al., 2019; Hooke 2023). Lateral bank erosion of meandering rivers is responsible for extensive destruction of

agricultural lands and landscape degradation and usually has very severe ecological and economic consequences (Langović et al., 2024). Furthermore, understanding and managing riverbank erosion is crucial to achieve a balance between ecological conservation, economic and sustainable development (Dragicevic et al., 2017). In the era of intense climate change as a direct determinant of hydrological variability and changes in the river regime, knowledge of the recent dynamics of the intensity of the above-mentioned processes is of great importance.

In addition, contemporary and observational research into the process of lateral channel migration and riverbank erosion employs numerous technical innovations that enable more precise and appropriate fieldwork and quantitative calculation of the intensity of the process, as well as its analysis and interpretation. In this context, the use of unmanned aerial vehicles (UAVs) is of particular importance for this type of research, as they allow constant observation of the Earth's surface in real time and its dynamics. The advances in photogrammetry and the availability of lightweight unmanned aerial vehicles or drones offer an advantageous alternative for the acquisition and creation of orthophoto images of the Earth's surface as well as secondary digital models of the topographic surface with high temporal and spatial resolution (Long et al., 2016, Dragićević et al., 2024).

The aim of this paper is to illustrate the possibilities of using modern unmanned aerial vehicles in the study of riverbank erosion and lateral channel migration in Serbia. The results of studies that implemented mentioned modern technologies (conducted on the Kolubara and South Morava rivers), have improved the possibilities of observing and quantifying these processes and facilitated field research.

Methods and data

The use of modern field survey methods was reviewed on the example of the meandering sections of the Kolubara and South Morava rivers from 2014. The use of drones has enabled the quantification of changes that have occurred in particular before and after extreme climatic-hydrological events. To date, monitoring of the riverbanks of the Kolubara and South Morava rivers has been carried out using unmanned aerial vehicles, which have different technical competences and different optical and flight capabilities. The first surveys were carried out in 2014 (June and December) with the SenseFly eBee aircraft and covered certain sections of the Kolubara River (total length of 7.5 km) (Dragićević et al., 2015; Dragićević et al., 2017). In the period 2019-2023, the surveys were carried out on the South Morava River (total length of 7.2 km) using several drones: Phantom 4 pro, Parrot ANAFI Work and DJI Air 2s drones (Langović, 2022). During the same period, surveys were also carried out on the individual meanders of the Kolubara River using Parrot Anafi Work and Dji Mini Pro 4 drones. All recordings were made from an altitude of 40-55 metres along a previously planned route, i.e. special software for planned terrain recordings (Pix4D Capture) was used. WebODM and the Pix4D Capture software were used for the subsequent processing of a large number of images, with the ultimate goal of obtaining clear orthophoto images of all surveyed sectors.

The resolution of the processed orthophotos was 4 cm/pixel. In the same way, digital relief models of the study areas were created, which were later used for a more detailed analysis of bank heights and changes in vegetation cover. Based on the data obtained, an analysis of the basic morphometric indicators was carried out, namely the sinusoidality and geometric elements of the meander curves, etc.

Results and discussion

The most important results of conducted research are singled out in this segment. Considering that one of the most important factors influencing the evolution of river channels is the occurrence of extreme hydrological events on the Kolubara River, the highest values of bank erosion intensity were recorded in 2014 (between 2.2 and 11.2 m depending on the defined meander) (Figure 1). A comparison of the results with previous studies on the riverbanks of the Kolubara River indicates a significant loss of soil in the period December 2013 - June 2014, when an intensity 2-3 times higher than in previous periods was recorded. In the Kolubara River Basin, riverbank erosion of 7.1 m occurred during the four-day passage of a flood wave (May 2014), which corresponds to 30.3 % of soil loss in four years of observation (2010–2014) (Dragićević et al., 2017).

Similar results were obtained for the South Morava River. The highest intensity of riverbank erosion of the South Morava River over a two-year research period (November 2019 - November 2021) was recorded on one of the meanders and amounted to 104.8 metres (4.3 m/month) (Figure 1). In the same period, the degradation of riverbank zone was 4.66 ha (Langović, 2022). However, the intra-annual analysis showed that the extreme hydrological event of January 2021 had the greatest impact on the intensity of the bank erosion process (over 50% of the total bank erosion for the observed period of only three months compared to the two-year study period. The importance of this process is also evidenced by the fact that most of the lost land belongs to agriculturally fertile land.

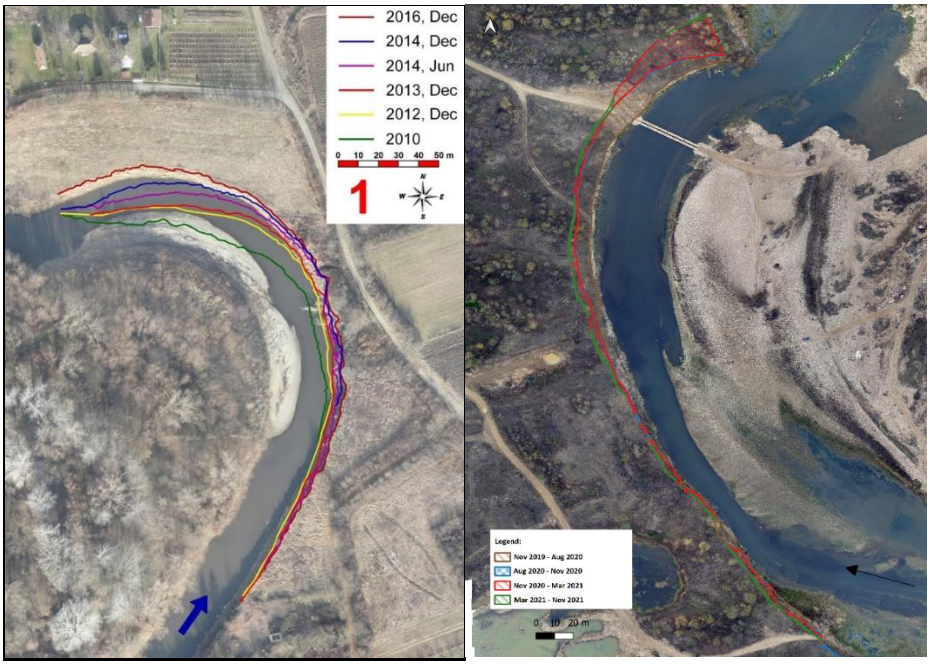

Figure 1. Examples of two meanders characterised by intensive riverbank erosion in recent times: Kolubara River (left) and South Morava River (right)

Conclusions

With the development of easily accessible unmanned aerial vehicles or drones for aerial photography, the precise positioning of riverbanks and the detailed research of their recent evolution and dynamics became possible. The use of these technologies and the associated software has proven to be very reliable and applicable and has opened up new possibilities and new fields of research in the geosciences, especially in fluvial geomorphology. Future work includes the use of even more advanced unmanned devices with improved optical equipment, sensors and numerous capabilities (Dji mavic 3M with multispectral camera).

References

Dragićević, S., Živković, N., Roksandić, M., Luković, J. & Kostadinov, S. (2015). *Recent state, intensity and consequences of the riverbank degradation of Kolubara River (Obrenovac Municipality)]*. Belgrade: University of Belgrade, Faculty of Geography.

Dragićević, S., Pripužić, M., Živković, N., Novković, I., Kostadinov, S., Langović, M., Milojković, B. & Čvorović, Z. (2017). Spatial and Temporal Variability of Bank Erosion during the Period 1930–2016: Case Study—Kolubara River Basin (Serbia). *Water*, 9, 748.

Dragićević, S., Langović, M., Lovrić, N., Milevski, I. & Tošić, R. (2024). The use of new technologies in the research of the fluvio-denudation process]. *Collection of papers VI congress of geographers "Where is geography going"*, Zlatibor, August 2024., 32-41. doi: 10.5937/KonGef24003D.

Hooke, J. (2023). Morphodynamics of active meandering rivers reviewed in a hierarchy of spatial and temporal scales. *Geomorphology*, 439(5), 108825.

Langović, M. (2022). Spatial and temporal dynamics of river bank erosion process (South Morava River). *Doctoral dissertation*. University of Belgrade, Faculty of Geography.

Langović, M., Popović, S., Dragićević, S., Stojanović, Ž. & Manić, E. (2024). Assessment of the Economic Consequences of Riverbank Erosion: The Case of the South Morava River, Serbia. *Water Economics and Policy*, doi: 10.1142/S2382624X24500036.

Long, N., Millescamps, B., Guillot, B., Pouget, F. & Bertin, X. (2016): Monitoring the topography of a dynamic tidal inlet using UAV imagery. *Remote Sensing,* https:// doi. org/ 10. 3390/ rs805 0387.

Menting, F. & Meijles, E. (2019). Local Factors Determining Spatially Heterogeneous Channel Migration in a Low-Energy Stream. *Water*, 11, 2149. DOI: doi:10.3390/w11102149.

Sylvester, Z., Durkin, P. & Covault, J. (2019). High curvatures drive river meandering. *Geology*, 47(3).

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[Poster]

Orbital precession of S-stars in Yukawa-like gravity: Case of bulk mass distribution

Vesna Borka Jovanović[1,*], Duško Borka[1], Alexander F. Zakharov[2] and Predrag Jovanović[3]

[1]Department of Theoretical Physics and Condensed Matter Physics (020), Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, P.O. Box 522, 11001 Belgrade, Serbia
[2]Bogoliubov Laboratory for Theoretical Physics, JINR, 141980 Dubna, Russia
[3]Astronomical Observatory, Volgina 7, P.O. Box 74, 11060 Belgrade, Serbia

[*]Correspondence: vborka@vinca.rs

Abstract: In this study we use a Yukawa-like correction of the Newtonian gravitational potential, proposed by C. Will (see Ref. Jovanović et al. 2024a) in order to obtain new bounds on graviton mass from the observed orbits of S-stars around Sgr A*, but taking into account bulk mass distribution (Jovanović et al. 2021). Orbital precession of investigated stars is influenced by other stars, gas and dark matter and it is expected that the stars represent the dominant component of the extended galactic mass distribution near the Sgr A*. We adopted a double power-law density profile of the bulk distribution of mass around supermassive black hole (SMBH) in the central regions of our galaxy. We also assumed that the orbital precession of S-stars is close to the prediction of General Relativity (GRAVITY Collaboration in 2020 and 2022) for Schwarzschild precession, but with a possible small discrepancy from it. By comparison of the observed orbits of bright stars (Gillessen et al. 2017) in the Galactic center with their simulated orbits in Yukawa-like gravitational potential, we estimated the constraints on the parameters of this Yukawa-like theory of gravity. Assuming that λ

represents the graviton Compton wavelength, we also found the corresponding upper bound of graviton mass. We also evaluated the parameters of the Yukawa-like gravity model in the case of different values of bulk mass density distribution of extended matter. The obtained results were then compared with our previous estimates (Jovanović et al. 2023, Jovanović et al. 2024b), as well as with the estimates of other authors. Also, obtained results are in a good agreement with the corresponding LIGO results. We believe that proposed method is a useful tool to evaluate parameters of the gravitational potential at the Galactic Center.

Keywords: alternative theories of gravity; supermassive black hole; stellar dynamics

Acknowledgement

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References

Gillessen, S.; Plewa, P.M.; Eisenhauer, F.; Sari, R.E.; Waisberg, I.; Habibi, M.; Pfuhl, O.; George, E.; Dexter, J.; von Fellenberg, S.; et al. An Update on Monitoring Stellar Orbits in the Galactic Center. Astrophys. J., 2017, 837, 30.

GRAVITY Collaboration; Abuter, R.; Amorim, A.; Bauböck, M.; Berger, J.P.; Bonnet, H.; Brandner, W.; Cardoso, V.; Clénet, Y.; de Zeeuw, P.T.; et al. Detection of the Schwarzschild precession in the orbit of the star S2 near the Galactic centre massive black hole. Astron. Astrophys. 2020, 636, L5.

GRAVITY Collaboration; Abuter, R.; Aimar, N.; Amorim, A.; Ball, J.; Bauböck, M.; Berger, J.P.; Bonnet, H.; Bourdarot, G.; Brandner, W.; et al. Mass distribution in the Galactic Center based on interferometric astrometry of multiple stellar orbits. Astron. Astrophys., 2022, 657, L12.

Jovanović, P.; Borka, D.; Borka Jovanović, V.; Zakharov, A. F. Influence of bulk mass distribution on orbital precession of S2 star in Yukawa gravity, Eur. Phys. J. D 75, 2021, 145

Jovanović, P.; Borka Jovanović, V.; Borka, D.; Zakharov, A. F. Constraints on Yukawa gravity parameters from observations of bright stars. J. Cosmol. Astropart. Phys., 2023, 3, 056.

Jovanović, P.; Borka Jovanović, V.; Borka, D.; Zakharov, A. F. Constraints on Graviton Mass from Schwarzschild Precession in the Orbits of S-Stars around the Galactic Center, 2024a, Symmetry 16, 397

Jovanović, P.; Borka Jovanović, V.; Borka, D.; Zakharov, A. F. Improvement of graviton mass constraints using GRAVITY's detection of Schwarzschild precession in the orbit of S2 star around the Galactic Center. Phys. Rev. D, 2024b, 109, 064046.

SECTION (MINI PROJECTS)

M1 Multidisciplinary perspectives in Astronomy & Earth Observation

M2 Geophysics and Astrophysics in the context of climate change, society and transport

M3 Big data in Astronomy and Earth Observations

M4 Introduction to statistical software and machine learning

PROGRAMME

Meeting on new trends in Astronomy & Earth Observation

November 25 – 29, 2024, Belgrade, Serbia

Monday (day 1) November 25, 2024		
Start	End	Session
15:00	15:30	Registration
15:30	15:45	Opening ceremony
15:45	16:15	Lecture Chairs: Vladimir Srećković & Aleksandra Kolarski
		Milan S. Dimitrijević Lecture
16:15	17:00	Welcome cocktail

Tuesday (day 2) November 26, 2024		
Start	End	Lectures Chair: Milan S. Dimitrijević
10:00	11:00	**Saša Dujko** Lecture
11:00	11:30	**Magdalena Christova** Lecture
11:30	**12:00**	**Coffee break**
Start	End	Lectures Chair: Saša Dujko
12:00	12:30	**Nikolay Bezuglov** Lecture
12:30	13:00	**Nenad Sakan** Lecture
13:00	13:30	**Zoran Mijić** Lecture
13:30	15:00	Lunch break
15:00	15:30	Lectures Chair: Nenad Sakan
		Milica Langović Lecture
15:30	16:00	**Milica Langović** Lecture
16:00	17:00	Work on mini projects

Wednesday (day 3) November 27, 2024		
Start	End	Lectures Chair: Nikola Veselinović
10:00	10:30	**Hans Eichelberger** Lecture
10:30	11:00	**Maja Kuzmanoski** Lecture
11:00	11:30	**Jelena Maljković** Lecture
11:30	**12:00**	**Coffee break**
Start	End	Lectures Chair: Maja Kuzmanoski
12:00	12:30	**Nikola Cvetanović** Lecture
12:30	13:00	**Nikola Veselinović** Lecture
13:00	13:30	**Zlatko Majlinger** Lecture
13:30	15:00	Lunch break
15:00	15:30	Lectures Chair: Jelena Maljković
		Sreten Jevremović Lecture
15:30	17:00	Work on mini projects
20:00	22:00	Conference dinner

Thursday (day 4) November 28, 2024		
Start	End	Lectures Chair: Aleksandra Kolarski
10:00	10:30	**Felix Iacob** Lecture
10:30	11:00	**Mihailo Savić** Lecture
11:00	11:30	**Filip Arnaut** Lecture
11:30	**12:00**	**Coffee break**
Start	End	Lectures Chair: Vladimir Srećković
12:00	12:30	**Nicolina Pop** Lecture
12:30	13:00	**Aleksandra Kolarski** Lecture
13:00	13:30	**Veljko Vujčić** Lecture
13:30	15:00	Lunch break
15:00	16:00	Poster Session Chair: Zoran Mijić
16:00	17:00	**Round table** ***New trends in Astronomy & Earth Observatios*** **By invitation only**

Friday (day 5) November 29, 2024		
Start	End	Session
10:00	11:00	Organizing committee meeting
11:00	11:30	Closing ceremony
11:30		**Departure**

AUTHORS' INDEX

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а) Астрономија -- Апстракти б) Астрофизика -- Апстракти в) Геологија -- Апстракти

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