Agentúra na podporu výskumu a vývoja
Mýtna 23, P.O.BOX 839 04, 839 04 Bratislava 32

Formulár ZK

Záverečná karta projektu

Názov projektu | Evidenčné číslo projektu **APVV-15-0458**

Interagujúce dvojhviezdy - kľúč k porozumeniu Vesmíru

Zodpovedný riešiteľ **RNDr. Augustín Skopal, DrSc.**

Príjemca **Astronomický ústav SAV**

Názov pracoviska, na ktorom bol projekt riešený

Astronomický ústav Slovenskej akadémie vied v Tatranskej Lomnici (žiadateľ),
Univerzita Pavla Jozefa Šafárika v Košiciach - Prírodovedecká fakulta (spoluriešiteľská organizácia),
Vihorlatská hvezdáreň Humenné (spoluriešiteľská organizácia).

Názov a štát zahraničného pracoviska, ktoré spolupracovalo pri riešení

- Astronomical Institute, Charles University Prague, CZ-180 00 Praha 8, V Holešovičkách 2, Czech Republic;
- Department of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, 61137 Brno, Czech Republic;
- Scientific Research Institute, Crimean Astrophysical Observatory, 298409 Nauchny, Crimea;
- Sternberg Astronomical Institute, Moscow State University, Universitetskij pr., 13, Moscow 119991, Russia;
- INAF – Osservatorio Astronomico di Padova, 36012 Asiago VI, Italy;
- Department of Astronomy, Kyoto University, Kyoto 606-8502, Japan;
- Tartu Observatory, University of Tartu, Observatooriumi 1, Tõravere, 616 02 Tartumaa, Estonnia;
- ELTE Eötvös Loránd University, Gothard Astrophysical Observatory, 9700 Szombathely, Hungary;
- Sonneberg Observatory, Sternwartestr. 32, 96515 Sonneberg, Germany .

Udelené patenty/podané patentové prihlášky, vynálezy alebo úžitkové vzory, ktoré sú výsledkami projektu

neaplikovateľné (projekt základného výskumu)

Najvýznamnejšie publikácie (knihy, články, prednášky, správy a pod.) zhrňujúce výsledky projektu – uveďte aj publikácie prijaté do tlače

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GARDE, Olivier - GRAHAM, Keith - LESTER, Tim - BOUTTARD, V. - LEMOULT, Thierry - SOLLECCHIA, U. - MONTIER, Jacques - BOYD, David. New outburst of the symbiotic nova AG Pegasi after 165 yr. In Astronomy and Astrophysics, 2017, vol. 604, article no. A48, p. 1-19. (5.014 - IF2016). (2017 - Current Contents, WOS, SCOPUS, NASA ADS). ISSN 0004-6361.

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7. SHAGATOVA, N. - SKOPAL, A. - SHUGAROV, S. YU. - KOMŽÍK, R. - KUNDRA, E. - TEYSSIER, F. Wind mass transfer in S-type symbiotic binaries III. Confirmation of a wind focusing in EG Andromedae from the nebular [OIII] 5007 line. Prijaté do Astronomy & Astrophysics. Dostupné na: https://arxiv.org/pdf/2012.08417.pdf

. Klasické novy a trpasličie novy:

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18. PARIMUCHA, Štefan - GAJDOŠ, Pavol - KUDAK, Viktor - FEDURCO, Miroslav - VAŇKO, Martin. Period variations of Algol-type eclipsing binaries AD And, TW Cas and IV Cas. In Research in Astronomy and Astrophysics, 2018, vol. 18, no. 4, article no. 47, p. 1-8. (1.227 - IF2017). ISSN 1674-4527.
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20. BROŽ, Miroslav - MOURARD, D. - BUDAJ, Ján - HARMANEC, Petr – SCHMITT, H. - TALLON-BOSC, I, - BONNEAU, D. - BOŽIĆ, H. - GIES, D. - ŠLECHTA, Miroslav. Optically

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23. HAMBÁLEK, Ľubomír - VAŇKO, Martin - PAUNZEN, Ernst - SMALLEY, B. T Tauri stars in SuperWASP and NSVS surveys. In Monthly Notices of the Royal Astronomical Society, 2019, vol. 483, no. 2, p. 1642-1654. (5.231 - IF2018). (2019 - Current Contents, WOS, SCOPUS, NASA ADS). ISSN 0035-8711.

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26. MALIUK, Andrii - BUDAJ, Ján. Spatial distribution of exoplanet candidates based on Kepler and Gaia data. In Astronomy and Astrophysics, 2020, vol. 635, article no. A191, p. 1-13. (2019: 5.636 - IF, Q1 - JCR, 2.174 - SJR, Q1 - SJR). (2020 - Current Contents, WOS, SCOPUS, NASA ADS). ISSN 0004-6361.

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34. SZABÓ, Gy. M. - PRIBULLA, Theodor - PÁL, A. - BÓDI, A. - KISS, L. L. - DEREKAS, A. The clockwork is moving on - a combined analysis of TESS and Kepler measurements of Kepler-13Ab. In Monthly Notices of the Royal Astronomical Society: Letters, 2020, vol. 492, no. 1, p. L17-L21. (2019: 5.356 - IF, Q1 - JCR, 1.964 - SJR, Q1 - SJR). (2020 - Current Contents, WOS, SCOPUS, NASA ADS). ISSN 1745-3925.
35. MANNADAY, Vineet Kumar - THAKUR, Parijat - JIANG, Ing-Guey - SAHU, D.K. - JOSHI, Y. C. - PANDEY, Anil K. - JOSHI, Santosh - YADAV, Ram Kesh - SU, Li-Hsin - SARIYA, Devesh P. - YEH, Li-Chin - GRIV, Evgeny - MKRTICHIAN, David - SHLYAPNIKOV, Aleksey - MOSKVIN, Vasilii - IGNATOV, Vladimir - VAŇKO, Martin - PUSKULLU, C. Probing transit timing variation and its possible origin with 12 new transtis of TrES-3b. In The Astronomical Journal, 2020, vol. 160, no. 1, article no. 47, p. 1-15. (2019: 5.838 - IF, Q1 - JCR, 2.374 - SJR, Q1 - SJR). (2020 - Current Contents, WOS, SCOPUS, NASA ADS). ISSN 0004-6256.
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Uplatnenie výsledkov projektu

1. Publikované výsledky projektu budú použité pre ďalší vedecký výskum v danom smere.
2. Výsledky projektu budú použité na výuku v rámci doktorandského štúdia. Konkrétne, do študijného plánu doktorandského štúdia na Astronomickom ústave SAV bude od akademického roku 2021/22 zaradený nový predmet, “An Introduction to Extrasolar Planets and Brown Dwarfs” - J. Budaj.
3. Výsledky projektu môžu byť použité aj pre popularizáciu vedy.
4. Tento typ projektu (základný výskum) nemá okamžitý realizačný výstup v praxi.

Súhrn výsledkov riešenia projektu a naplnenia cieľov projektu v slovenskom jazyku (max. 20 riadkov)

Ústredným cieľom projektu APVV-15-0458 bol výskum interagujúcich dvojhviezd v špecifických štádiách vývoja a extrasolárnych planét, ktorých vlastnosti a vývojové cesty nám umožňujú lepšie porozumieť cirkulácii hmoty vo vesmíre. Tento cieľ sme dosiahli analýzou astronomických pozorovaní, ktoré sme získali na observatóriách žiadateľskej ako aj spoluriešiteľských organizácií, v rámci medzinárodnej spolupráce a z archívov vesmírnych misií. Výskum mladých T Tauri hviezd nám umožnil lepšie porozumieť vývojovému štádiu gravitačne zrútených mračien medzihviezdnej hmoty až po normálne hviezdy. Prítomnosť rozsiahlych akréčnych diskov v týchto sústavách nám pomohla lepšie pochopiť aj vznik planetárnych sústav v okolí iných hviezd našej Galaxie. V rámci výskumu extrasolárnych planét sa nám podarilo vysvetliť záhadu tzv. Boyianovej hviezdy, okolo ktorej obieha rozpadávajúca sa exoplanéta zahalená v prachových mračnách. Asi po 100 miliónoch rokov sa T Tauri objekty stanú normálnymi hviezdami, ktoré sa často vyvíjajú v

páročh, či vo viac-násobných sústavách, ako tzv. tesné dvojhviezdy. V rámci ich výskumu sa nám podarilo vypracovať doteraz najkomplexnejší model silno-interagujúcej tesnej dvojhviezdy beta-Lyrae ako aj model najtesnejšej známej štvorhviezdy VW LMi. Ďalší vývoj hmotnejších hviezd vedie ku vzniku mŕtvych objektov s extrémnou gravitáciou, ktorých prítomnosť v interagujúcej dvojhviezde môže byť príčinou silných explózií s výronom značného množstva hmoty do vesmíru. Náš presný popis týchto úkazov pre klasickú novu V339 Del a symbiotickú hviezdu AG Peg navrhol ich ďalšie teoretické modelovanie. Výsledky, ktoré sme získali v rámci riešenia projektu, "Interagujúce dvojhviezdy - Kľúč k porozumeniu Vesmíru", prispeli k lepšiemu porozumeniu cyklu vývoja hviezd a ich planetárnych sústav, v ktorom kľúčovým procesom je akrécia hmoty na centrálny objekt, následná formácia akréčnych diskov s možnosťou vzniku extrémnych vzplanutí, ktoré zabezpečujú cirkuláciu hmoty vo vesmíre.

Súhrn výsledkov riešenia projektu a naplnenia cieľov projektu v anglickom jazyku (max. 20 riadkov)

The pivotal aim of the APVV-15-0458 project was the investigation of interacting binaries at specific stages of their evolution and extrasolar planets, the properties and evolutionary paths of which allowed us a better understanding of the circulation of matter in the Universe. We achieved this aim by analyzing astronomical observations obtained at observatories of the applicant as well as at cooperating organizations, in the framework of our international co-operation, and from archives of space missions. Research of young T Tauri stars allowed us to better understand the evolutionary stage of gravitationally compacted clouds of interstellar matter to normal stars. The presence of extended accretion disks in these systems aided us to understand also the formation of planetary systems around other stars in our Galaxy. Within the research of extra-solar planets we were able to explain the mystery of the so-called Boyian's star that is orbited by a crumbling exoplanet shrouded in dust clouds. After about 100 millions of years, T Tauri objects become to be normal stars, often evolving as binaries or multiple systems, the so-called close binaries. Within their research, we managed to elaborate currently the most complex model of strongly interacting close binary beta-Lyrae as well as the model of the closest known fourfold-star VW LMi. Following evolution of more massive stars leads to creation of dead stars with extreme gravity, the presence of which in interacting binary can cause strong explosions with ejection of a large amount of mass into the Universe. Our precise description of such events for classical nova V339 Del and the symbiotic star AG Peg proposed also their further theoretical modeling. The results we achieved by solving the project, "Interacting binaries - Key for the Understanding of the Universe", contributed to better understanding the cycle of the stars and their planetary systems evolution, where the accretion of mass onto the central object represents the key process, being followed by formation of accretion disks, and, eventually, leading to extreme outbursts responsible for the circulation of matter in the Universe.