The Exo-Striker



by Trifon Trifonov

▲□▶ ▲□▶ ▲ 三▶ ▲ 三▶ - 三 - のへぐ

What is the Exo-Striker?

Fast and convient GUI toolbox for exoplanet orbital analysis and N-body simulations

| Tra | nsit TTV Astr. Activity Sample corr. | Orb. Evol. | session | * Shells | Extra Plots | Data inspector | Notes Calc | ulator Stdout | /Stderr |
|---|--|---|--|--|--|---|---|---|--|
| RN RN evec GLS GLS< | | | new copy remov Stellar mass 1.0000 Epoch[JD] 0.0 mrs[mk] 0.0000 wms[mk] 0.0000 | You are naming a development version of the Exo-Striker (ver. 0.81). This version is almost full, but down are still some parts of the tool, which are in a 'versit in programs' state. Freese, by Ead required to be used to dow with the newest version. | | | | | |
| 0.6 | | | x ² me 0.0000 | result | | | | | |
| | | | BIC 0.00 | | | | | | |
| 0.4 | | | N data 0 DOF 0 AMD stable | | | | | | |
| 0.2 | 12 | | More stat. info | | | | | | |
| 8.0 8.0 | | | Fast Fortran RV R options Simplex | | | | | | |
| 0.4 0.2 | 0.1 0.2 0.3 0.4 B Transk O TTV O Aske O MYTransk O | 0.5 0.6 0.7 0.8 JD [days] MV=TTV _ MV=Astr. | 0.9 Nobel Repeated | | | | | | |
| 0.4 0.2 | 0.1 0.2 0.3 0.4 Transk TTV Astr. MrvHansk Mrs. GPparam. Stellarparam. Models pa | 0.5 0.6 0.7 0.8 LID [days] MV+TTV M/+Astr. ram. Limits and Priors Neody Pla | 0.9 Protory © gepenan Nithilize Fit Run MCMC, Run Nientaum Run orb. end RV Auto fit © suu/Ma hJcA | P. RV data | Transit dat | a TTVs Astr | Advity | Limits and Priors | |
| 0.4 0.2 et para | 0.1 0.2 0.3 0.4 Tasisit TTV Adtr. MortTasisit Granam. Additional Stellar param. Models par 1-3 Planets 6-6 Planets 7-9 | 0.5 0.6 0.7 0.8 LID [days] MV=TTV MV=Aatz. ram. Limits and Prises Nebedy Ha | 0.9 Protection Protections 0.9 Ren MOXA Ran oth evol Wedato Ri 0 e.u.Mda https://www.sec.int.com/ 0 e.u.Mda https://wwwwwwwwwwwwwwwwww | P. RV data Offset | Transit dat | a TTVs Astr RV trends Dat | Addwity | Limits and Priors | |
| 0.4 0.2 it para rets 1 dl | 0.1 0.2 0.3 0.4 174106 TTV Actor (Privilando) m. CP param. Solitar param. Models par 1741065279 1740065279 1740065279 1740065279 1740065279 1740065279 17400579 17400579 17400579 17400579 17400579 17400579 | 0.5 0.6 0.7 0.8 IDD(ting) Wr-TIV Mr/state. am. Umits and Priors Netody Pla Planet 2 Trictonymaa (8-14-0.000 | Pesco e prices Prision Prices Prision Prices Prision Prices Price | P. RV data Offset | Transit dat s and jitters | a TTVs Astr RV trends Dat RV affurt (m/i) | Addwity a options | Umits and Priors RV Jates (m/s) | |
| 0.4 0.2 it para nets 1 f] n(6] | 0.1 0.2 0.3 0.4 Transit TTV Addic Mrv1Tansit mr Gragoon Sediropoon Models a 10 Breat 44 Haves 79 11 Here 1 12 Breat 45 Haves 79 13 Here 4000 14 Here 4000 14 Here 4000 15 Here 40000 15 Here 4000 15 Here 40000 15 Here 4000 15 Here 40000 15 Here 40000 15 H | 0.5 0.6 0.7 0.8 JDC [den] IKY-TTV [WY-kdz, ram Umits and Priors]N-body Pfie Planet 2]S400000000 E -(r/-0.000]S400000000 E -(r/-0.000 | Preckay * grapman | P. RV data Offset | Transit dat s and jitters data 1 | a TTVs Astr RV trends Dat BV offust [m/d] 800008 | Addwity a options 2 +/-0.000 | Umits and Priors RV Jater [m/k] 0.00000 | t 4-0.000 |
| 0.4 0.2 et pars srets 1 d] jtt[s] | 0.1 0.2 0.3 0.4 Tasik TVV Act: MV*Tasik m (Para) Selitoparam. Models as Planet 44 (Havet) 79 Here 1 0.0000000 (+/ 0.000 0.0000000 (+/ 0.000 0.0000000 (+/ 0.000) | 0.5 0.6 0.7 0.8 ID-Ditem] INV-TIV INV-66LL. Iam UHRIS and Pries IN-body Pla Planet 2 ISE0000000 8/1/-0.000 ISE0000000 8/1/-0.000 ISE0000000 8/1/-0.000 | | P. RV data Offset X | Transit dat s and jitters data 1 data 2 | a TTVs Astr RV trends Dat BV offset [m/l] 0.00000 0.00000 | Addivity a options = +/- 0.000 = +/- 0.000 = +/- 0.000 | Umits and Priors RV Jater [m/k] 0.00000 | ± +/- 0.000 ± +/- 0.000 |
| 0.4 0.2 et pars sriets 1 d] jtt[deg] | 0.1 0.2 0.3 0.4 g Tasak TTV Astc. MrrHaak m Paran Salaranom. Models au 13 Plants 44 Hants 75 14 Januar 14 14 14 14 14 14 14 14 14 14 14 14 14 | 05 0.6 0.7 0.8 LDG (dam) Mr+TTV Mr+AdL: mail Uint2 and Prioss №4060 Pfe Planet 2 1016/0000000 Fr+0.800 0 00000000 Fr+0.800 0 00000000 Fr+0.800 0 00000000 Fr+0.800 | | P. RV data Offset X. | Transit dat s and jitters data 1 data 2 data 2 data 2 | a TTVs Astr RV trends Dat RV offset (m/s) 6 400000 1 6 90000 | Addivity a options = +/-0.000 = +/-0.000 = +/-0.000 | Umits and Priors RV Jater [m/k] 0.0000 0.0000 | |
| 0.4 0.2 et pari ints 1 [deg] [deg] | 0.1 0.2 0.3 0.4 | 0.5 0.6 0.7 0.8 Lip (dam) Wr.TW Wr.4ktr. wam. Limits and Priats. N-backy Plas 0.164,0000000 0.144,000 0.144,0000000 0.144,0000000000000000000000000000000000 | | P. RV data Offset | Transit dat | a TTVs Astr RV trends Dab BV offset (m)(6 80000 6 80000 6 90000 | Activity a options 0 +/-0.000 0 +/-0.000 0 +/-0.000 0 +/-0.000 | Umits and Priors RV-Jative [m/k] 0.00000 0.00000 0.00000 | 2 +/- 0.000 2 +/- 0.000 2 +/- 0.000 2 +/- 0.000 |
| 0.4 0.2 et para arets 1 [d] [m/5] [d(deg) [d(deg) [d(deg) [d(deg)] | 0.1 0.2 0.3 0.4 | 05 0.6 0.7 0.8 LDG (dam) INVTTV INVALU: INVTTV INVALU: INVALUATION INVALUE INVALUATION INVALUE INVALUATION INVALUE INVALU | | P. RV data Offset | Transit dat and jitters data 1 data 1 data 2 data 2 data 3 data 4 | a TTVS Astr RV trends Dat BV offset (sv)(6.00000 6.00000 6.00000 6.00000 | Adduity a options 0 +/-0.000 0 +/-0.000 0 +/-0.000 0 +/-0.000 | Umits and Priors RV Jataer [m/b] 0.00000 0.00000 0.00000 0.00000 | 2 +√-0.000 2 +√-0.000 2 +√-0.000 2 +√-0.000 |
| 0.4 0.2 et pars arets 1 [d] [d(deg) [deg] [deg] [deg] | 0.1 0.2 0.3 0.4 | 0.5 0.6 0.7 0.8 Located where the second s | | P. RV data Offset X X X X X X X X | Transit dat and jitters data 1 data 1 data 2 data 3 data 4 data 5 data 6 | a TTVs Astr RV trends Dat BV offuet [m/l] 0.00000 0.00000 0.00000 0.00000 0.00000 | Activity a options 0 +/-0.000 0 +/-0.000 0 +/-0.000 0 +/-0.000 0 +/-0.000 | W Jitter [m/b] 0.00000 0.00000 0.00000 0.00000 0.00000 | 2 +√-0.000 2 +√-0.000 2 +√-0.000 2 +√-0.000 2 +√-0.000 |
| o.4 o.2 ext para anets 1 [d] [deg] [deg] [deg] [deg] [deg] [deg] | 0.1 0.2 0.3 0.4 Tanak TV Act. Nr/Tanak Para Seliraram. Modelgan 19 Resci 4 Rayo 79 19 Resci 4 Rayo 79 10 Resci 79 10 Res | 0.5 0.6 0.7 0.8 DDSdard IntriTV (MrAdd. ram, Linits and Palas) 10000000 + 45000 10000000 + 45000 1000000 + 45000 10000000 + 45000 10000000 + 45000 10000000 + 45000 10000000 + 45000 1000000 + 45000 1000000 + 45000 10000000 + 45000 1000000 + 450000 1000000 + 45000 1000000 + 450000 1000000 + 450000000 1000000 + 45000000 1000000 + 4500000 1000000 + 4500000000 100000000 + 4500000000000000 10000000000000000000000 | | P. RV data X X X X X X X X X X X X X | Transit data and jitters data 1 data 1 data 2 data 2 data 2 data 4 data 5 data 6 data 5 data 6 data 6 data 6 data 6 data 7 data | a TTVs Astr RV trends Dat B offset (m/s) 6 80000 6 80000 6 80000 6 80000 6 80000 6 80000 | Atthety explanations 0 +/ 6.800 0 +/ 6.800 0 +/ 6.800 0 +/ 6.800 0 +/ 6.800 0 +/ 6.800 | Umits and Prices | 1 ↓ 0.000 2 ↓ 0.000 |
| 0.4 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 | a1 a2 a3 a4 a2 a3 a4 a4 a2 a3 a4 a4 a3 a2 a4 a4 a3 a4 a4 a4 a4 a4 a4 a4 | 0.5 0.6 0.7 0.8 DDS/bed INFTU 0 R0vAdZ INFTU 0 R0vAdZ INFO 0 R0 Pilos 0 Pilos I 0 Pilos 2 I 0 Pilos 2 I 0 Pilos 0 I 0 Pilos 0 | | P. RV data Offset X X X X X X X X X X X X X X X X X X X | Transit dat and jitters data 1 data 2 data 2 data 3 data 4 data 5 data 6 data 6 data 6 data 6 data 6 data 6 | a TTVs Astr RV trends Dat BV offset (sn)(6.00000 6.00000 6.00000 6.00000 6.00000 6.00000 6.00000 | Activity 0 y/- 8.000 0 y/- 8.000 | Units and Priors RV Jitzer (m/s) 6.00000 0.0000 0.00000 0.00000 0.00000 | ☐ 1/- 0.000 ☐ 1/- 0.000 |
| (0.4 0.2 (0.2 (0.2) (0.2 | 81 82 83 84 8 Tank Tary Adc. Perflaxel. 8 Tark Tark Perflaxel. 9 8 Tark Family Perflaxel. 9 9 Tark Family Perflaxel. 9 9 1 Status 1 4 500 9 1 Status 1 4 500 9 1 1 Status 1 4 500 1 4 500 1 4 500 1 | 0.5 0.6 0.7 0.8 D.D.Bard NorTV Mondal: Plans Units and Flass Meadoy Pla Plans 1111000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 111000000 - 4-500 11100000000 - 4-500 11100000000 - 4-500 11100000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 1110000000 - 4-500 11100000000 - 4-500 11100000000 - 4-500 11100000000 - 4-500 11100000000 - 4-500 11100000000000000000000000000000000 | 0 | P. RV data Offset X X X X X X X X X X X X X X | Transit dat and jitters data 1 data 1 data 2 data 2 data 4 data 4 data 5 data 4 data 5 data 6 data 5 data 6 data 6 data 6 data 1 | a TTVs Astr RV trends Dat BV offuet [w/k] 6 400000 6 400000 6 400000 6 400000 6 400000 6 400000 6 400000 6 400000 6 400000 | Attbilly applies 2 +/- 8 000 2 +/- 2 | Umits and Prices RV Jitter [m/d] 0.00000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000 0 | E ↓ 0.000 E ↓ 0.000 |
| 4 0.4 6 0.2 1 | 0.1 0.2 0.3 0.4 Nati TV Jacc North Sati North Sati Nati TV Jacc North Sati North Sati 10 Potentiati North Sati Nort Sati North Sati | 0.5 0.6 0.7 0.8 DDS/and mrTTV Mrthat mrTTV Mrthat 155000000 H 45000 155000000 H 45000 155000000 H 45000 155000000 H 45000 155000000 H 45000 155000000 H 45000 15500000 H 45000 155000000 H 450000 155000000 H 450000 15500000 H 450000 15500000 H 450000 15500000 H 450000 15500000 H 450000 15500000 H 4500000 15500000 H 4500000 155000000 H 4500000 155000000 H 45000000 155000000 H 45000000 155000000 H 45000000 155000000 H 45000000 155000000 H 45000000 155000000 H 450000000 155000000 H 450000000 155000000 H 4500000000 1550000000 H 4500000000000000000000000000 | 0.7 → 0.99000 0.7 → 0.99000 1.7 → 0.0000 0.7 → 0.00000 0.7 → 0.0000 0.7 → 0.00000 0.7 → 0.000000 0.7 → 0.000000 0.7 → 0.0000000 0.7 → 0.00000000 0.7 → 0.00000000000000000000000000000000 | P. RV data X X X X X X X X X X X X X X X X X X | Trensit dat and jitters data 1 data 1 data 2 data 5 data 5 data 5 data 6 data 5 data 6 data 6 data 6 data 6 data 6 data 6 data 6 data 7 data 6 data 7 data 7 | a TTVs Astr RV trends Dat 6 00000 0 00000 | Addielby | Imits and Priors NV. Jitter [mit] 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 | ¹ √ - 0.000 |

Available on the GitHub

https://github.com/3fon3fonov/exostriker

(inspired by the "Systemic" project. http://www.stefanom.org/systemic/)

◆ □ ▶ ◆ □ ▶ ▲ □ ▶ ▲ □ ▶ ● ○ ○ ○ ○

What is it made of?

| | Library | Reference |
|-------------------------------|----------------------|--|
| Exo-Striker (Ver. 0.81) | | |
| Core code | Python & Fortran77 | |
| GUI | Python/PyQt5 | https://riverbankcomputing.com |
| Models (Keplerian and N-body) | | |
| RV | Internal | |
| Transit | batman | Kreidberg (2015) |
| Astrometry | AstroMod | Schiwy et al. in prep. |
| TTV | ttv-fast | Deck et al. (2014) |
| GP | celerite | Foreman-Mackey et al. (2017) |
| Fitting schemes | | |
| Best fit optimization | Internal / Scipy | |
| MCMC | emcee | Foreman-Mackey et al. (2013) |
| Nested sampling | dynesty | Speagle (2019) |
| Signal search & filtering | | |
| RV | GLS, MLP | Zechmeister & Kürster (2009) |
| Transit | TLS, wotan | Hippke et al. (2019a,b) |
| Activity analysis | Internal | |
| Stability analysis | Swift (modified) | Levison & Duncan (2013) |
| Interactive plotting | pyqtgraph (modified) | http://www.pyqtgraph.org |
| Interactive shell | Jupyter, Bash, GPT-3 | https://jupyter.org |
| Huge pub. RV database | Exo-Striker RVBanks | |
| > 64 000 HIRES RVs | HIRES/HIRES NZP | Butler et al. (2017), Tal-Or et al. (2019) |
| > 212 000 HARPS RVs | HARPS RVbank | Trifonov et al. (2020) |

GUI layout



IPython: home/tito

File Edit View Search Terminal Help

tito@terminator:-\$ ipython3
Python 3.6.9 (default, Apr 18 2020, 01:56:04)
Type 'copyright', 'credits' or 'license' for more information
IPython 7.2.0 -- An enhanced Interactive Python. Type '?' for help.

In [1]: import exostriker # to load the Exo-Striker as a library

In [2]: import exostriker.lib.RV_mod as rv # to load a specific module, e.g. the RV fitting module

In [3]: fit = rv.signal_fit(name="hip5364") # creates the fit class object

In [4]: fit.add_dataset("hip5364_lick","./datafiles/hip5364.vels",0.0,10.0) # add RV dataset

In [5]: fit.add_planet(K=50,P=400,e=0,w=0,M0=0,i=90,cap=0) # add planet 1 (approx. init. param.)

In [6]: fit.add_planet(K=50,P=700,e=0,w=0,M0=180,i=90,cap=0) # add planet 2

In [7]: fit.fitting() # let's optimize!

In [8]: fit.P[0],fit.P[1] # e.g. to get the bestfit Periods of planet 1 & 2
Out[8]: (404.22299345507207, 751.8970043845964)

In [9]: rv.run_mcmc(fit, burning_ph=1000, mcmc_ph=5000, threads=20) #for a basic MCMC run

A brief demo of the Exo-Striker

* Analysis of a 2:1 MMR pair discovered on multi-telescope, precision Doppler data, under 5 min.

◆□▶ ◆□▶ ◆ □▶ ◆ □▶ ○ □ ○ ○ ○ ○

Transit period search



TESS light curve of WASP-6, interactively de-trended and analyzed.

Global data analysis



A TESS light curve + RV data of a nearby transiting planet GJ 486 b (Trifonov et al. 2021a).

GP modeling

| Transit TTV Activity Sample corr. Orb. Evol. | TICXXXXXX * | Shells Extra Plots Data inspector Text Editor Calculator Stdout/Stderr |
|--|--|--|
| S PRIVOC CLS CLSOC MLP Window(DPT) | new copy remove Stellar mass 0.8230 0.8230 Epoch [JD] 243807 0.9730 wms [m/s] 19.7302 x² x1xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx | Jupper Bashshell pogshell Or(11) (0) array(10,007, 0,0958, 0.0958,, 0,0957, 0,0957, 0,0957)), 2) (1) (1) (1) (1557, 0,1551, 0,155,, 0,1554, 0,1557, 0,1557)), 2) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1 |
| 20 40 40 40 40 40 40 40 40 40 40 40 40 40 | N data 46 DOF 26 AMD stable Simplex • LM4 • Dynamical Septerian Initialize Fit Run MCMC Run Nest.samp. Bin of war MR Alun fit | 00121: (0: array(10.6421), 0.0224), 0.02709,, 0.03188, 0.03703, 0.04270), 0.04221, 2.012, 2.012, 3.01, |
| ○ Transit ○ TTV ● RV+Transit ○ RV+TTV | ● e,ω,Ma ○ h,kλ | In [3]: |
| et param. GP param. Limits and Priors Stellar param. Models param. | N-body Plot opt. | RV data Transit data TTVs Activity Limits and Priors |
| GP Transit GP | | RV off. and jitt. RV trend Tran. off. and jitt. Tran. trend Limb-dark. param. |
| Use transit GP | | |
| Use transit GP HO Kernel Rot. Kernel Matern-3/2 | | Though 00/off min 00/off may 00/Dt min 00/Dt may |
| Use transit GP HO Kernel Rot. Kernel Matern-3/2 Rot Rotal T | | ✓ bounds RV off. min RV off. max RV jitt. min RV jitt max data1 ✓ -140.00 Φ -100.00 Φ ✓ -0.01 Φ 50.00 Φ |
| Use transit GP HO Kernel Rot. Kernel Matern-3/2 se Rot. Kernel V molinde V nonsests no | READ ME !!! | |
| Use transit CP HO Kernel Rot. Kernel Matern-3/2 Se Rot. Kernel V mplitude V 0.00018212 \$ +/-0.000 | READ ME !!! | W bound RV off. min RV off. max RV jitt. min RV jitt. max data1 0 140.00 0 1000 0 0.01 0 50.00 0 data2 0 -110.00 0 70.00 0 0.01 0 50.00 0 data3 0 -140.00 0 100.00 0 0.01 0 50.00 0 |
| Use transit GP HO Kernel Kot Kernel Kotern 3/2 Kernel Kot (0.00001512) Kernel Kern | READ ME III | W books FV off. min FV off. max FV jit. min FV jit. max data1 1 1 0 |
| Ube trank CP 340 Gerenii (Korred) (Korred) mplitude (V 0.00018122 c) /+ 0.000 (V 2101075000 c) /+ 0.000 (V 2010012700 c) /+ 0.000 (V 0.000 C) (V 0.000 | READ ME III | Weissen RV off. min RV off. max RV jitt. min RV jitt. min RV jitt. max data1 100.00 0 000.00 0 0 |
| Ube transit (P SHO Rennel Rott, Kennel M Mattern 3/2 mpRibude V V 000018172 (2 4000 1 40000 Link to 8V CP? V 24.30520040 (1 40000 Link to 8V CP? V 24.30520040 (1 40000 Link to 8V CP? V) | READ ME III | Weight RV off. min RV off. max RV jett. min RV jett. min RV jett. max data1 0 -100.00 0 00.00 10 0.000 0 data2 0 -100.00 0 0.00 0 <t< td=""></t<> |
| Ube trank CP 340 Garrell & Rotreel & Matern 3/2 wropibude V 000001622 0 4-0.000 470 00001622 0 4-0.000 470 00001622 0 4-0.000 470 00001622 0 4-0.000 470 00001622 470 000 470 0000162 470 000 470 0000 470 0000 470 0000 470 0000 470 0000 470 0 | READ ME III | Baseline RV off: max RV off: max RV off: max RV off: max data 0 +00.00 0 0.00 0 0.00 0 data 0 +00.00 0 0.00 0 0.00 0 0.00 0 data 0 000000.00 0 0.00 0 0 0.00 0 0.00 0 0.00 0 0.00 0 0.00 0 0.00 0 0.00 0 0.00 0 0.00 0 0 0.00 0 0 0.00 0 0 0.00 0 0 0.00 0 0 0.00 0 0 0.00 |
| Ube transfer SigG Karelen Normel Matern 3/2 Hundlinker V 00011212 V 0.000 Hundlinker V 00011212 V 0.000 Hundlinker V 00011212 V 0.000 Hundlinker V 00011212 V 0.000 Hundlinker V 00011212 V 0.000 Garantees are HOT in ludg | READ ME 1 | Bounds RV off. min RV off. max RV jitt. min RV jitt. min RV jitt. min RV jitt. max data1 0 -100.00 0 0 0.00 0 0 0.00 0 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <td< td=""></td<> |

Transit and RV GP components are shared and show an excellent agreement (Trifonov et al. 2021b).

What is next?

- Combined modeling with astrometry (ongoing).
- Improved photo-dynamical model.
- Readthedocs webpage.

Stay tuned!

Feedback and help in further development will be highly appreciated! Supported in part by the BNSF program "VIHREN-2021" project No. KP-06-DV/5