Caso03

October 29, 2025

1 Evaluación del caso "Kicked Kepler con impulsos periódicos"

Analizamos un sistema Kepleriano perturbado: una estrella central y una partícula ligera que recibe impulsos periódicos en velocidad. El objetivo es encontrar masas dentro de rangos estrechos que mitiguen la respuesta caótica y favorezcan órbitas cuasi periódicas pese a las perturbaciones.

> **Interpretación** - La métrica de Lyapunov indica qué tan sensible es la órbita ante el "kick" periódico; valores más bajos implican trayectorias controladas. - La penalización de periodicidad ayuda a que el estado tras cada ciclo completo de impulsos permanezca próximo al inicial.

1.1 Preparación del entorno

Localizamos la carpeta raíz `two_body`, la añadimos a `sys.path` y definimos `PARENT` para acceder a utilidades compartidas. Así evitamos problemas de importación sin importar dónde se ejecute el notebook.

[1]:
```
import sys
from pathlib import Path

PROJECT_ROOT = Path.cwd().resolve()
while PROJECT_ROOT.name != "two_body" and PROJECT_ROOT.parent != PROJECT_ROOT:
    PROJECT_ROOT = PROJECT_ROOT.parent

if PROJECT_ROOT.name != "two_body":
    raise RuntimeError("No se encontró la carpeta two_body")

PARENT = PROJECT_ROOT.parent  # directorio que contiene a two_body
if str(PARENT) not in sys.path:
    sys.path.insert(0, str(PARENT))

print("PYTHONPATH += ", PARENT)
```

```
PYTHONPATH +=
C:\Users\emicr\Documents\CODIGOS_FUENTES\TrabajoTerminal\collision_of_two_bodies
```

1.2 Dependencias clave del pipeline

Importamos la configuración (`Config`), el controlador híbrido, los visualizadores 2D/3D, el adaptador REBOUND base y utilidades como `numpy` y `Path` para manejar resultados y artefactos.

```
[2]: from two_body import Config, set_global_seeds
     from two_body.core.telemetry import setup_logger
     from two_body.logic.controller import ContinuousOptimizationController
     from two_body.presentation.visualization import Visualizer as PlanarVisualizer
     from two_body.presentation.triDTry import Visualizer as Visualizer3D
     from two_body.simulation.rebound_adapter import ReboundSim
     import numpy as np
     from pathlib import Path  # si quieres guardar animaciones/figuras
```

1.3 Instrumentación de rendimiento

Activamos `PERF_TIMINGS_ENABLED` y cargamos las herramientas de la suite de tiempos (`time_block`, `latest_timing_csv`, etc.). Esto permitirá inspeccionar los costos de cada fase del experimento Kicked Kepler.

```
[3]: import os
     os.environ["PERF_TIMINGS_ENABLED"] = "1"
     os.environ.setdefault("PERF_TIMINGS_JSONL", "0")

     from two_body.perf_timings.timers import time_block
     from two_body.perf_timings import latest_timing_csv, read_timings_csv,␣
      ↪parse_sections_arg, filter_rows
```

1.4 Formato de logging amigable en notebook

Creamos un `NotebookHandler` que acumula los mensajes del optimizador y los imprime progresivamente. Mantiene el contexto de ejecución visible sin saturar la salida con trazas crudas.

```
[4]: import logging
     from IPython.display import display, Markdown

     class NotebookHandler(logging.Handler):
         def __init__(self):
             super().__init__()
             self.lines = []

         def emit(self, record):
             msg = self.format(record)
             self.lines.append(msg)
             print(msg)  # aparece en la celda conforme avanza

     handler = NotebookHandler()
     handler.setFormatter(logging.Formatter("[%(asctime)s] %(levelname)s -␣
      ↪%(message)s"))

     logger = setup_logger(level="INFO")
     logger.handlers.clear()          # quita otros handlers previos
     logger.addHandler(handler)
logger.setLevel(logging.INFO)
```

1.5 Configuración del escenario "Kicked Kepler"

Definimos el diccionario `case` con: - Integración rápida (`t_end_short = 300`) y una integración larga exigente (`t_end_long = 8000`) para validar periodicidad. - Estado inicial Kepleriano casi circular (`r0`, `v0`) más un "kick" ligero en `vy`. - Rangos de masa muy estrechos para la estrella y el test particle, lo que obliga al optimizador a trabajar con ajustes finos. - Parámetros evolutivos moderados (`pop_size = 80`, `max_epochs = 15`) y `periodicity_weight = 0.08` para penalizar la deriva tras múltiples impulsos. - Tres parámetros nuevos (`kick_period`, `kick_delta_v`, `kick_target`) que describen la perturbación periódica.

[ ]:
```
# Kicked Kepler
case = {
    "t_end_short": 300.0,
    "t_end_long": 8000.0,
    "dt": 0.05,
    "integrator": "whfast",    # o "ias15" para pasos adaptativos
    "r0": ((-1.0, 0.0, 0.0), (1e-3, 0.0, 0.0)),
    "v0": ((0.0, -0.8, 0.0), (0.0, 25.0, 0.0)),
    "mass_bounds": (
        (0.99, 1.01),       # masa central
        (9.5e-5, 1.1e-4),   # partícula test
    ),
    "G": 1.0,
    "pop_size": 80,
    "n_gen_step": 1,
    "mutation": 0.08,
    "max_epochs": 15,
    "top_k_long": 10,
    "headless": False,
    "periodicity_weight": 0.08,
    "kick_period": 2*np.pi,         # nuevo
    "kick_delta_v": (0.0, 0.03, 0.0),
    "kick_target": 1,
}
```

[6]:
```
from two_body.logic.controller import ContinuousOptimizationController
from two_body.core.config import Config
from two_body.core.telemetry import setup_logger
from two_body.core.cache import HierarchicalCache

_kick_keys = (
    "kick_period",
    "kick_delta_v",
    "kick_target",
)
```

```
config_kwargs = {k: v for k, v in case.items() if k not in _kick_keys}

cfg = Config(**config_kwargs)
logger = setup_logger()
```

1.6 Adaptador REBOUND con impulsos periódicos

Subclasamos `ReboundSim` para construir `KickedKeplerSim`, que aplica un incremento de velocidad `Δv` al cuerpo objetivo cada `kick_period`. Registramos la función en `post_timestep_modifications` y monkeypatcheamos el módulo `rebound_adapter` para que el resto del pipeline use este integrador "pateado".

[7]:
```
from two_body.simulation.rebound_adapter import ReboundSim as _BaseReboundSim
kick_period = case["kick_period"]
kick_delta_v = case["kick_delta_v"]
kick_target = case["kick_target"]

class KickedKeplerSim(_BaseReboundSim):
    def __init__(self, **kwargs):
        super().__init__(**kwargs)
        self._kick_period = kick_period
        self._kick_delta_v = kick_delta_v
        self._kick_target = kick_target

    def setup_simulation(self, *args, **kwargs):
        sim = super().setup_simulation(*args, **kwargs)
        next_kick = {"t": sim.t + self._kick_period}
        dv = self._kick_delta_v

        def apply_kick(_ptr=None):
            while sim.t >= next_kick["t"] - 1e-12:
                p = sim.particles[self._kick_target]
                p.vx += dv[0]
                p.vy += dv[1]
                p.vz += dv[2]
                next_kick["t"] += self._kick_period

        sim.post_timestep_modifications = apply_kick
        return sim

# Monkeypatch para que todo el pipeline use el adaptador pateado
from two_body.simulation import rebound_adapter
rebound_adapter.ReboundSim = KickedKeplerSim
```

[8]:
```
print(cfg.mass_bounds, cfg.max_epochs, cfg.eval_budget)
```

```
((0.99, 1.01), (9.5e-05, 0.00011)) 15 10000
```

1.7 Ejecución del controlador híbrido

Instanciamos `Config`, el `logger` y el `ContinuousOptimizationController`. Envolvemos `controller.run()` dentro de `time_block("notebook_run")` para medir la ejecución completa (GA + refinamiento continuo) bajo el régimen de impulsos periódicos.

[9]:
```
with time_block("notebook_run", extra={"source": "Caso01.ipynb"}):
    controller = ContinuousOptimizationController(cfg, logger=logger)
    results = controller.run()
```

```
[2025-10-29 00:08:23,033] INFO - Starting optimization | pop=80 | dims=2 |
time_budget=1800.0s | eval_budget=10000
```

```
c:\Users\emicr\anaconda3\envs\grav2body\Lib\site-
packages\rebound\__init__.py:58: UserWarning: pkg_resources is deprecated as an
API. See https://setuptools.pypa.io/en/latest/pkg_resources.html. The
pkg_resources package is slated for removal as early as 2025-11-30. Refrain from
using this package or pin to Setuptools<81.
  import pkg_resources
```

```
[2025-10-29 00:08:30,959] INFO - Epoch 0 | new global best (short)
lambda=0.002206 | fitness=-618.268673 | penalty=7728.330839 | masses=(1.009713,
9.9e-05)
[2025-10-29 00:08:56,358] INFO - Epoch 0 complete | lambda_short=0.002206 |
fitness_short=-618.268673 | lambda_best=0.002206 | fitness_best=-618.268673 |
evals short/long=80/10 | total evals=90 | radius=0.1000
[2025-10-29 00:09:05,065] INFO - Epoch 1 | new global best (short)
lambda=0.001779 | fitness=-618.268179 | penalty=7728.330005 | masses=(1.009785,
9.9e-05)
[2025-10-29 00:09:29,913] INFO - Epoch 1 complete | lambda_short=0.001779 |
fitness_short=-618.268179 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=180 | radius=0.1000
[2025-10-29 00:10:01,650] INFO - Epoch 2 complete | lambda_short=0.002204 |
fitness_short=-618.275932 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=270 | radius=0.1000
[2025-10-29 00:10:36,036] INFO - Epoch 3 complete | lambda_short=0.002221 |
fitness_short=-618.279806 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=360 | radius=0.1000
[2025-10-29 00:11:06,864] INFO - Epoch 4 complete | lambda_short=0.001720 |
fitness_short=-618.276619 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=450 | radius=0.1000
[2025-10-29 00:11:37,301] INFO - Epoch 5 complete | lambda_short=0.002203 |
fitness_short=-618.281250 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=540 | radius=0.1000
[2025-10-29 00:12:06,490] INFO - Stagnation detected; reseeding around best
candidate.
[2025-10-29 00:12:06,490] INFO - Epoch 6 complete | lambda_short=0.001665 |
fitness_short=-618.283278 | lambda_best=0.001779 | fitness_best=-618.268179 |
evals short/long=80/10 | total evals=630 | radius=0.0900
[2025-10-29 00:12:07,325] INFO - Epoch 7 | new global best (short)
```

```
lambda=0.001822 | fitness=-618.268013 | penalty=7728.327389 | masses=(1.01,
0.00011)
[2025-10-29 00:12:09,691] INFO - Epoch 7 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=720 | radius=0.0900
[2025-10-29 00:12:10,784] INFO - Epoch 8 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=810 | radius=0.0900
[2025-10-29 00:12:11,907] INFO - Epoch 9 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=900 | radius=0.0900
[2025-10-29 00:12:12,799] INFO - Epoch 10 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=990 | radius=0.0900
[2025-10-29 00:12:13,873] INFO - Epoch 11 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=1080 | radius=0.0900
[2025-10-29 00:12:14,672] INFO - Stagnation detected; reseeding around best
candidate.
[2025-10-29 00:12:14,672] INFO - Epoch 12 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=1170 | radius=0.0810
[2025-10-29 00:12:15,425] INFO - Epoch 13 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=1260 | radius=0.0810
[2025-10-29 00:12:16,303] INFO - Epoch 14 complete | lambda_short=0.001822 |
fitness_short=-618.268013 | lambda_best=0.001822 | fitness_best=-618.268013 |
evals short/long=80/10 | total evals=1350 | radius=0.0810
[2025-10-29 00:12:16,303] INFO - Optimization completed | epochs=15 | evals=1350
| best lambda=0.001822 | wall=233.3s
```

1.8 Métricas de referencia y solución óptima

Calculamos el fitness del punto central de los rangos de masa (`center`) y lo comparamos con `results["best"]`. Obtenemos `baseline_details` para revisar cómo afectan los kicks al exponente de Lyapunov y conservamos `metrics` para graficar la evolución de y del fitness.

[10]:
```
metrics = controller.metrics
results
```

[10]:
```
{'status': 'completed',
 'best': {'masses': [1.01, 0.00011],
  'lambda': 0.0018216158084116186,
  'fitness': -618.2680127057457,
  'm1': 1.01,
  'm2': 0.00011},
 'evals': 1350,
 'epochs': 15}
```

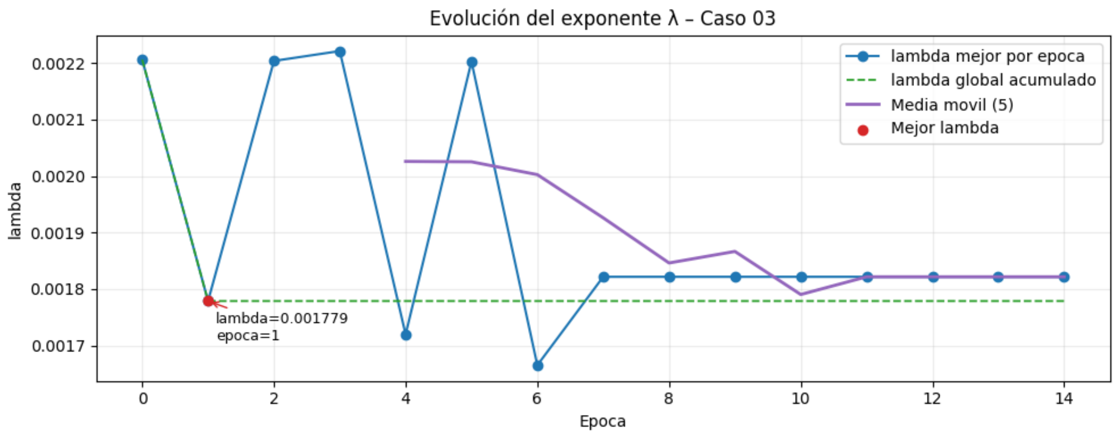
[11]:
```python
from two_body.core.cache import HierarchicalCache
from two_body.logic.fitness import FitnessEvaluator

cache = HierarchicalCache()
evaluator = FitnessEvaluator(cache, cfg)

center = tuple((lo + hi) / 2.0 for lo, hi in cfg.mass_bounds)

baseline_fits, baseline_details = evaluator.evaluate_batch(
    [center],
    horizon="long",
    return_details=True,
)
baseline_fit = baseline_fits[0]
baseline_lambda = baseline_details[0].get("lambda")
if baseline_lambda is None or not np.isfinite(baseline_lambda):
    baseline_lambda = -baseline_fit

best_payload = results.get("best", {})
best_fit = best_payload.get("fitness")
best_lambda = best_payload.get("lambda")
if best_lambda is None and best_fit is not None:
    best_lambda = -best_fit

print(
    f"lambda inicial = {baseline_lambda:.6f}, "
    f"lambda optimo = {best_lambda if best_lambda is not None else 'N/A'}"
)
```

```
lambda inicial = 0.000007, lambda optimo = 0.0018216158084116186
```

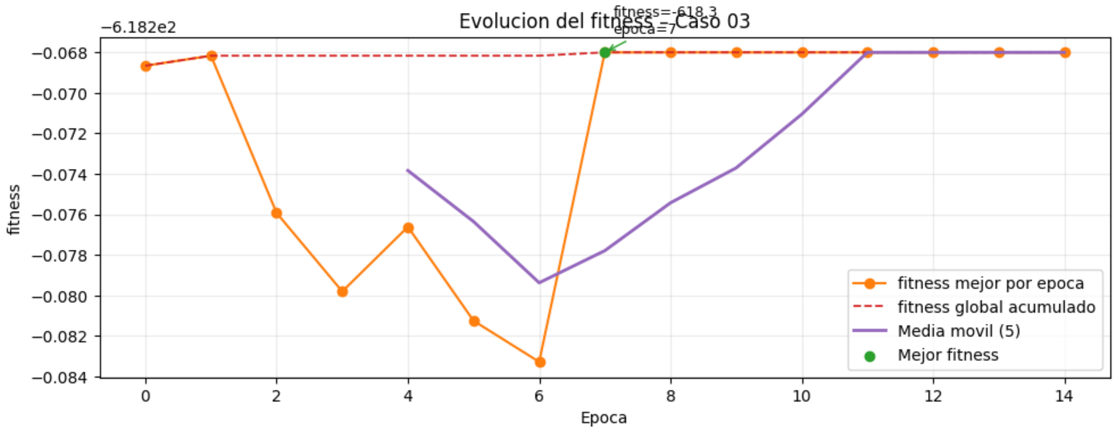
1.9 Visualización y seguimiento de convergencia

Mostramos: - `plot_lambda_evolution` y `plot_fitness_evolution` para estudiar cómo responde el GA ante los impulsos repetidos. - Las trayectorias integradas con las masas óptimas (`xyz_tracks`) tanto en vista rápida 2D (`quick_view`) como en la animación 3D final, verificando si la órbita se mantiene acotada tras sucesivos kicks.

[12]:
```python
viz_3d = Visualizer3D(headless=cfg.headless)

_ = viz_3d.plot_lambda_evolution(
    lambda_history=metrics.best_lambda_per_epoch,
    epoch_history=metrics.epoch_history,
    title="Evolución del exponente  - Caso 03",
    moving_average_window=5,   # opcional
)
```



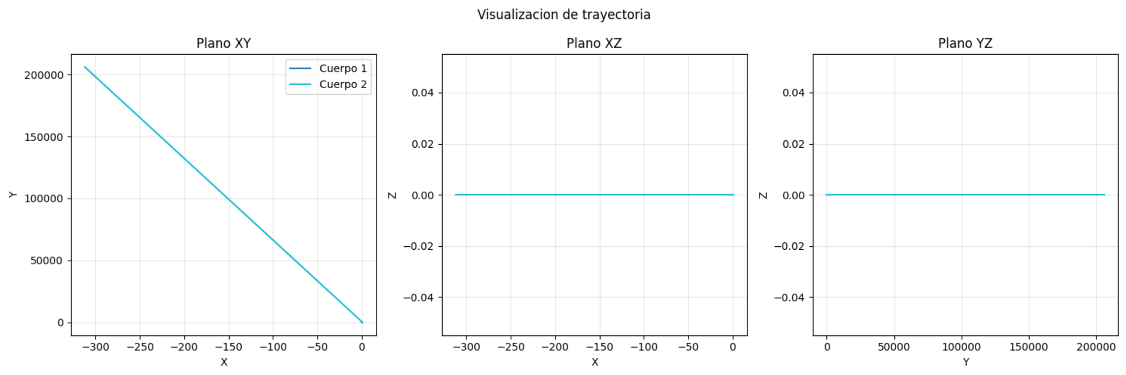
[13]:
```
_ = viz_3d.plot_fitness_evolution(
    fitness_history=metrics.best_fitness_per_epoch,
    epoch_history=metrics.epoch_history,
    title="Evolucion del fitness - Caso 03",
    moving_average_window=5,
)
```



[14]:
```
sim_builder = ReboundSim(G=cfg.G, integrator=cfg.integrator)
best_masses = tuple(results["best"]["masses"])

def _slice_vectors(vectors, count):
    if len(vectors) < count:
        raise ValueError("Config no tiene suficientes vectores iniciales")
    return tuple(tuple(float(coord) for coord in vectors[i]) for i in␣
 ↪range(count))
```

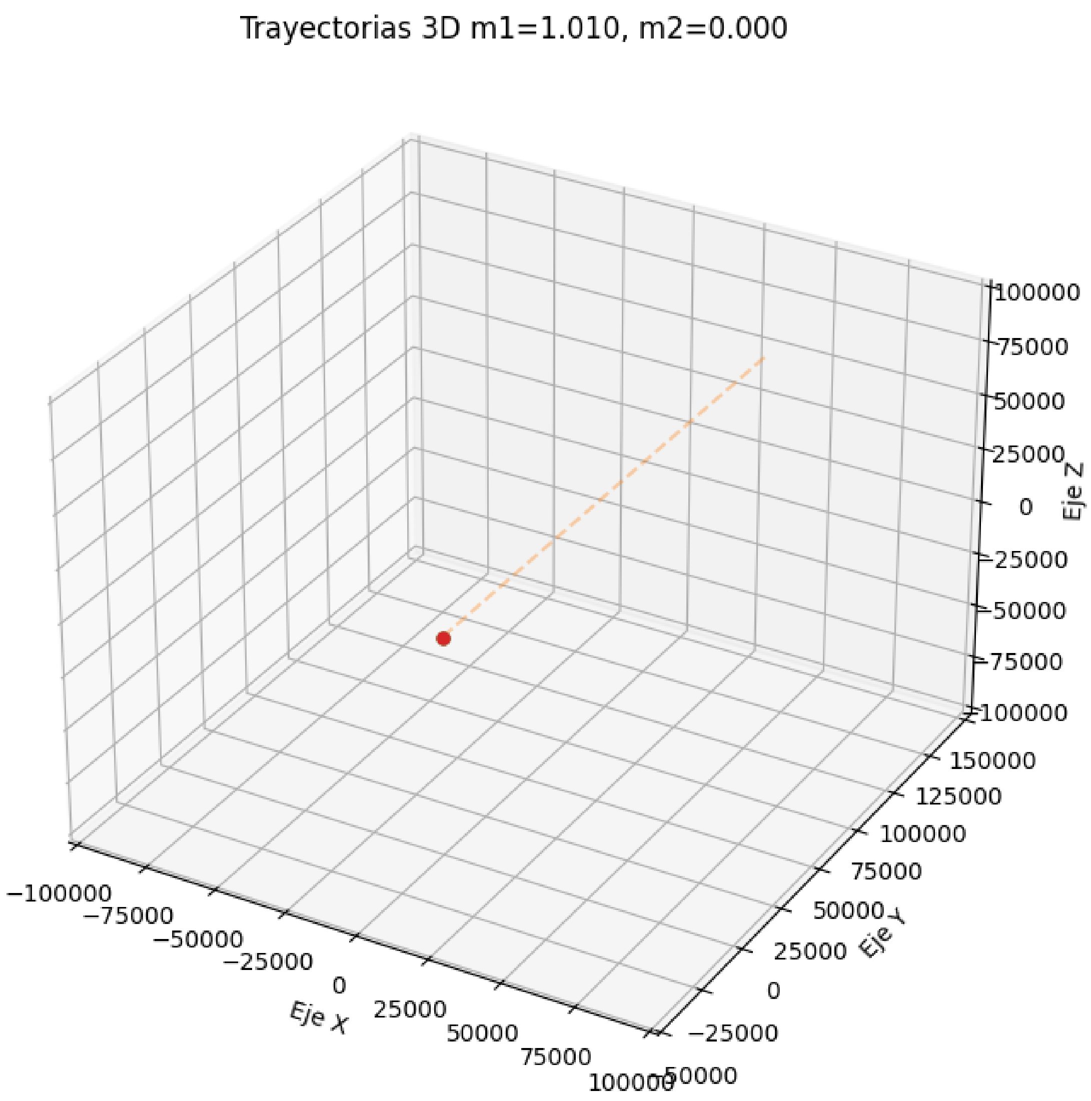
```
r0 = _slice_vectors(cfg.r0, len(best_masses))
v0 = _slice_vectors(cfg.v0, len(best_masses))

sim = sim_builder.setup_simulation(best_masses, r0, v0)
traj = sim_builder.integrate(sim, t_end=cfg.t_end_long, dt=cfg.dt)
xyz_tracks = [traj[:, i, :3] for i in range(traj.shape[1])]
```

[15]:
```
viz_planar = PlanarVisualizer(headless=cfg.headless)
_ = viz_planar.quick_view(xyz_tracks)
```



[16]:
```
from IPython.display import HTML

import matplotlib as mpl
mpl.rcParams['animation.embed_limit'] = 1024  # MB
```

[17]:
```
viz_3d = Visualizer3D(headless=False)

anim = viz_3d.animate_3d(
    trajectories=xyz_tracks,
    interval_ms=50,
    title=f"Trayectorias 3D m1={best_masses[0]:.3f}, m2={best_masses[1]:.3f}",
    total_frames=len(xyz_tracks[0]),
)
#HTML(anim.to_jshtml())
```



1.10 Exportación de animaciones

Configuramos un `FFMpegWriter`, creamos `artifacts/caso03` (ajusta la ruta si lo prefieres) y guardamos los MP4 de la trayectoria y de la comparación de masas. Puedes modificar `fps`, `bitrate` o el preset de ffmpeg si necesitas acelerar el render.

```
[ ]: from matplotlib.animation import FFMpegWriter  # o PillowWriter para GIF

writer = FFMpegWriter(
    fps=20,
    bitrate=1800,
    extra_args=["-vcodec", "libx264", "-preset", "ultrafast", "-crf", "28"]
)
```

```
output_path = Path("artifacts/caso01")                # ajusta a tu gusto
output_path.mkdir(parents=True, exist_ok=True)

anim.save(output_path / "trayectoria_optima.mp4", writer=writer)
```

```
[ ]: anim_mass = viz_3d.plot_mass_comparison(
         original_masses=center,
         optimized_masses=best_masses,
         body_labels=[f"Cuerpo {i+1}" for i in range(len(best_masses))],
         title="Comparativa de masas (Caso 01)",
     )
     #HTML(anim_mass.to_jshtml())
```

```
[ ]: anim_mass.save(output_path / "comparativa_masas.mp4", writer=writer)
```

1.11 Reporte de tiempos de ejecución

Leemos el CSV generado por la instrumentación, mostramos una vista preliminar y agregamos estadísticas por sección para detectar qué partes del flujo (simulación con kicks, evaluación larga, etc.) dominan el costo computacional en este caso.

```
[ ]: import pandas as pd

     csv_path = latest_timing_csv()
     display(f"Usando CSV: {csv_path}")

     rows = read_timings_csv(csv_path)
     df = pd.DataFrame(rows)
     display(df.head(10))

     # Estadísticas rápidas por sección
     section_stats = (
         df.groupby("section")["duration_us"]
         .agg(["count", "mean", "sum"])
         .sort_values("sum", ascending=False)
     )
     section_stats
```

```
'Usando CSV: C:
 ↪\\Users\\emicr\\Documents\\CODIGOS_FUENTES\\TrabajoTerminal\\collision_of_two_bodies\\two_bo
 ↪csv'

                                 run_id  epoch  batch_id  individual_id  \
0  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
1  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
2  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
3  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
4  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
```

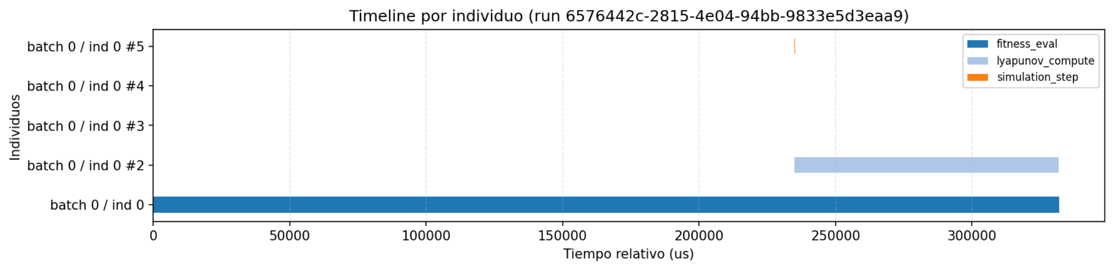
```
5  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
6  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
7  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
8  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0
9  6576442c-2815-4e04-94bb-9833e5d3eaa9      0         0              0

           section        start_ns          end_ns  duration_us  \
0  simulation_step  42514194440700  42514194489200           48
1  simulation_step  42514194542400  42514194553800           11
2  simulation_step  42514194578800  42514194587300            8
3  simulation_step  42514194604900  42514194611200            6
4  simulation_step  42514194627100  42514194633800            6
5  simulation_step  42514194647600  42514194653500            5
6  simulation_step  42514194665600  42514194671400            5
7  simulation_step  42514194683200  42514194689500            6
8  simulation_step  42514194700800  42514194706100            5
9  simulation_step  42514194717000  42514194722800            5

                                          extra
0         {'step': 0, 'dt': 0.05, 't_target': 0.05}
1          {'step': 1, 'dt': 0.05, 't_target': 0.1}
2  {'step': 2, 'dt': 0.05, 't_target': 0.15000000…
3          {'step': 3, 'dt': 0.05, 't_target': 0.2}
4         {'step': 4, 'dt': 0.05, 't_target': 0.25}
5  {'step': 5, 'dt': 0.05, 't_target': 0.30000000…
6  {'step': 6, 'dt': 0.05, 't_target': 0.35000000…
7          {'step': 7, 'dt': 0.05, 't_target': 0.4}
8         {'step': 8, 'dt': 0.05, 't_target': 0.45}
9          {'step': 9, 'dt': 0.05, 't_target': 0.5}
```

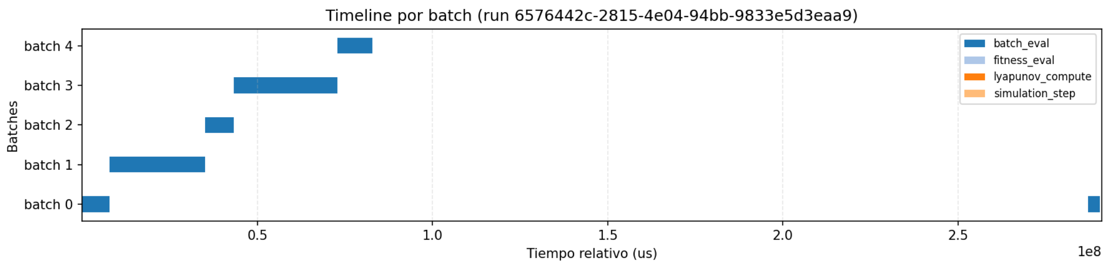
[ ]:
```
                        count          mean        sum
section
notebook_run                1  2.909833e+08  290983335
batch_eval                 31  9.335158e+06  289389902
fitness_eval             1348  2.146547e+05  289354498
lyapunov_compute          708  4.081245e+05  288952175
simulation_step      15495994  5.257146e+00   81464707
ga_main                    15  3.681453e+04     552218
crossover                 709  4.398237e+02     311835
mutation                  709  1.815261e+02     128702
selection_tournament      709  1.708843e+02     121157
```

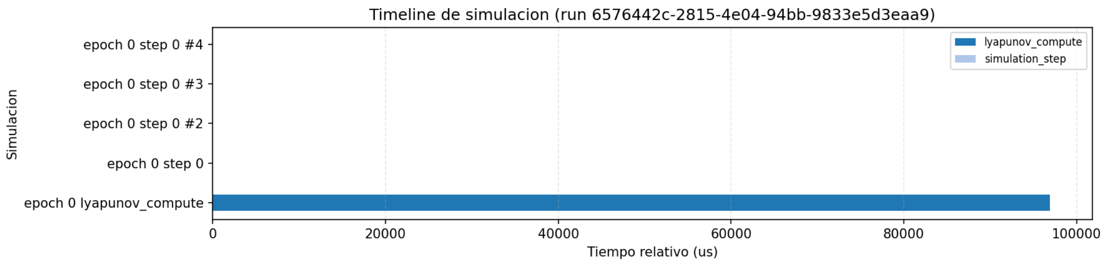
[ ]:
```python
import os
import subprocess
from pathlib import Path
from IPython.display import Image, display
```

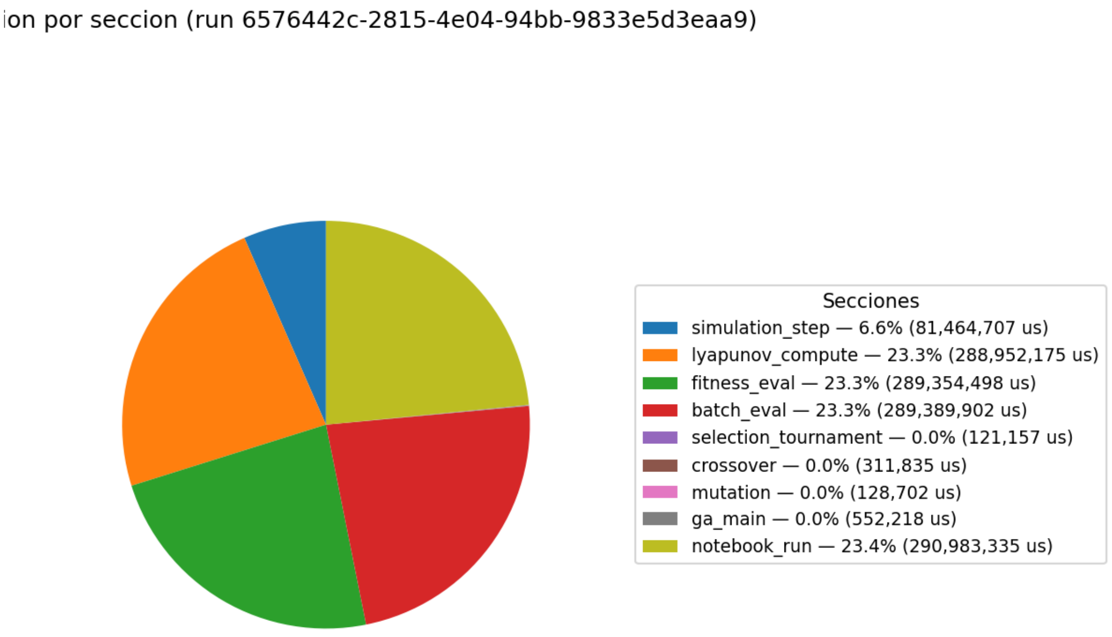
```python
PROJECT_ROOT = Path.cwd()
while PROJECT_ROOT.name != "two_body" and PROJECT_ROOT.parent != PROJECT_ROOT:
    PROJECT_ROOT = PROJECT_ROOT.parent

env = os.environ.copy()
env["PYTHONPATH"] = str(PROJECT_ROOT)

run_id = df["run_id"].iloc[0]
cmd = [
    sys.executable,
    "scripts/plot_timings.py",
    "--run-id", str(run_id),
    "--top-n", "5",
]


print("Ejecutando:", " ".join(cmd))
result = subprocess.run(cmd, cwd=PROJECT_ROOT, env=env, text=True,␣
 ↪capture_output=True)
print(result.stdout)
print(result.stderr)
result.check_returncode()

reports_dir = PROJECT_ROOT / "reports"

display(
    Image(filename=str(reports_dir / f"timeline_by_individual_{run_id}.png")),
    Image(filename=str(reports_dir / f"timeline_by_batch_{run_id}.png")),
    Image(filename=str(reports_dir / f"timeline_simulation_{run_id}.png")),
    Image(filename=str(reports_dir / f"pie_sections_{run_id}.png")),
)
```

```
Ejecutando: c:\Users\emicr\anaconda3\envs\grav2body\python.exe
scripts/plot_timings.py --run-id 6576442c-2815-4e04-94bb-9833e5d3eaa9 --top-n 5
Graficas guardadas en C:\Users\emicr\Documents\CODIGOS_FUENTES\TrabajoTerminal\c
ollision_of_two_bodies\two_body\reports
```




Timeline por batch (run 6576442c-2815-4e04-94bb-9833e5d3eaa9)
batch 4
batch 3
batch 2
batch 1
batch 0
Batches
batch_eval
fitness_eval
lyapunov_compute
simulation_step
0.5
1.0
1.5
2.0
2.5
1e8
Tiempo relativo (us)


Timeline de simulacion (run 6576442c-2815-4e04-94bb-9833e5d3eaa9)
epoch 0 step 0 #4
epoch 0 step 0 #3
epoch 0 step 0 #2
epoch 0 step 0
epoch 0 lyapunov_compute
Simulacion
lyapunov_compute
simulation_step
0
20000
40000
60000
80000
100000
Tiempo relativo (us)


ion por seccion (run 6576442c-2815-4e04-94bb-9833e5d3eaa9)
Secciones
simulation_step — 6.6% (81,464,707 us)
lyapunov_compute — 23.3% (288,952,175 us)
fitness_eval — 23.3% (289,354,498 us)
batch_eval — 23.3% (289,389,902 us)
selection_tournament — 0.0% (121,157 us)
crossover — 0.0% (311,835 us)
mutation — 0.0% (128,702 us)
ga_main — 0.0% (552,218 us)
notebook_run — 23.4% (290,983,335 us)