Potential Synergies of the collaboration

Round Table

Jorge Segovia – jsegovia@upo.es

Long-term members and main (not all) research lines

- Group of UGR

  - E. Gamiz – Flavor physics LQCD: Semileptonic decays of heavy-light mesons and muon g-2.
  - J.I. Illana – BSM: SUSY, Higgs sector, SM-EFT.
  - M. Masip – BSM: SUSY models, neutrino physics.

- Group of UHU-UPO

  - M. Gomez – String theory applied to Beyond Standard Model Physics.
  - J. Rodríguez-Quintero – Low-energy QCD analysis using non-perturbative methods.
  - F. de Soto - Analysis of the Gauge Sector of QCD by means of LQCD computations.
  - J. Segovia – (Non-)relativistic theoretical approaches to the bound-state problem in QCD.

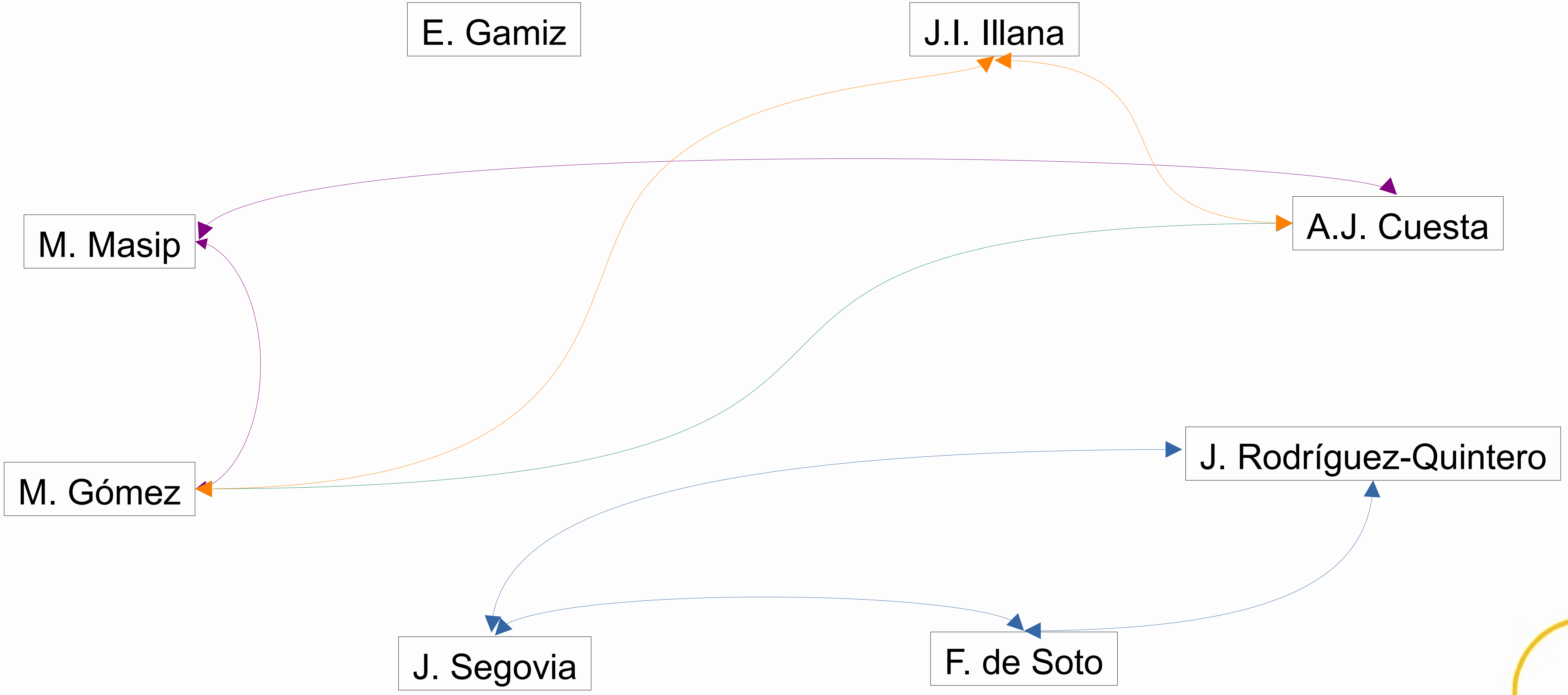
- Group of UC

  - A.J. Cuesta – Theory and Data Analysis applied to Dark Energy, Dark Matter and Exoplanets.

Long-term members and main (not all) research lines

- (Political) questions:
  - Is there a way of strengthen the UC group? Is it better to merge UC with UGR and just having two nodes?
  - Up to now, there are 4 BSM and 4 SM physicists, which is a good number; However, should we think to enlarge the group?
  - If enlarging is a good idea or even keeping a constant number of physicists → What are the possible ways of stabilizing young researches, attracting new talents, for the future?
  - We are solving the issue of making all of us Principal Investigators (PI's) by rotating roles to those who need it more at an appropriate time. However, we all know it could be good to have projects located at the university: Is there a way of rotating this also? Is this so crucial now? Less nodes will help: UGR-UC .vs. UHU-UPO.
  - What about enrollement of young researches: attracting new students by proposing co-tutored TFGs and TFMs, local financial support, … Acting as a group.

Actual synergies of the collaboration



Manuel Masip

See Jorge’s slide + general discussion.

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Collider and Astroparticle Pheno

- Lepton flavour violation: SUSY, ... Little Higgs (+ J.M. Pérez-Poyatos ⇒ PhD-thesis)
- Cosmic rays, neutrinos, dark matter (+ M. Masip, M. Gutiérrez, et al.)

Cosmology of an axion-like majoron

(+ A.J. Cuesta, M. Gómez, M. Masip)

- Hubble tension
- Impact on BBN (Lithium problem?)

EuCAPT

(European Consortium for Astroparticle Theory) https://www.eucapt.org/

- Representative of UGR-UCO-UHU joint institution at EuCAPT Council
- Involved in outreach (task force)

⟶ 3rd EuCAPT Annual Symposium (CERN, May 31 - June 2, 2023)
https://indico.cern.ch/event/1218730/

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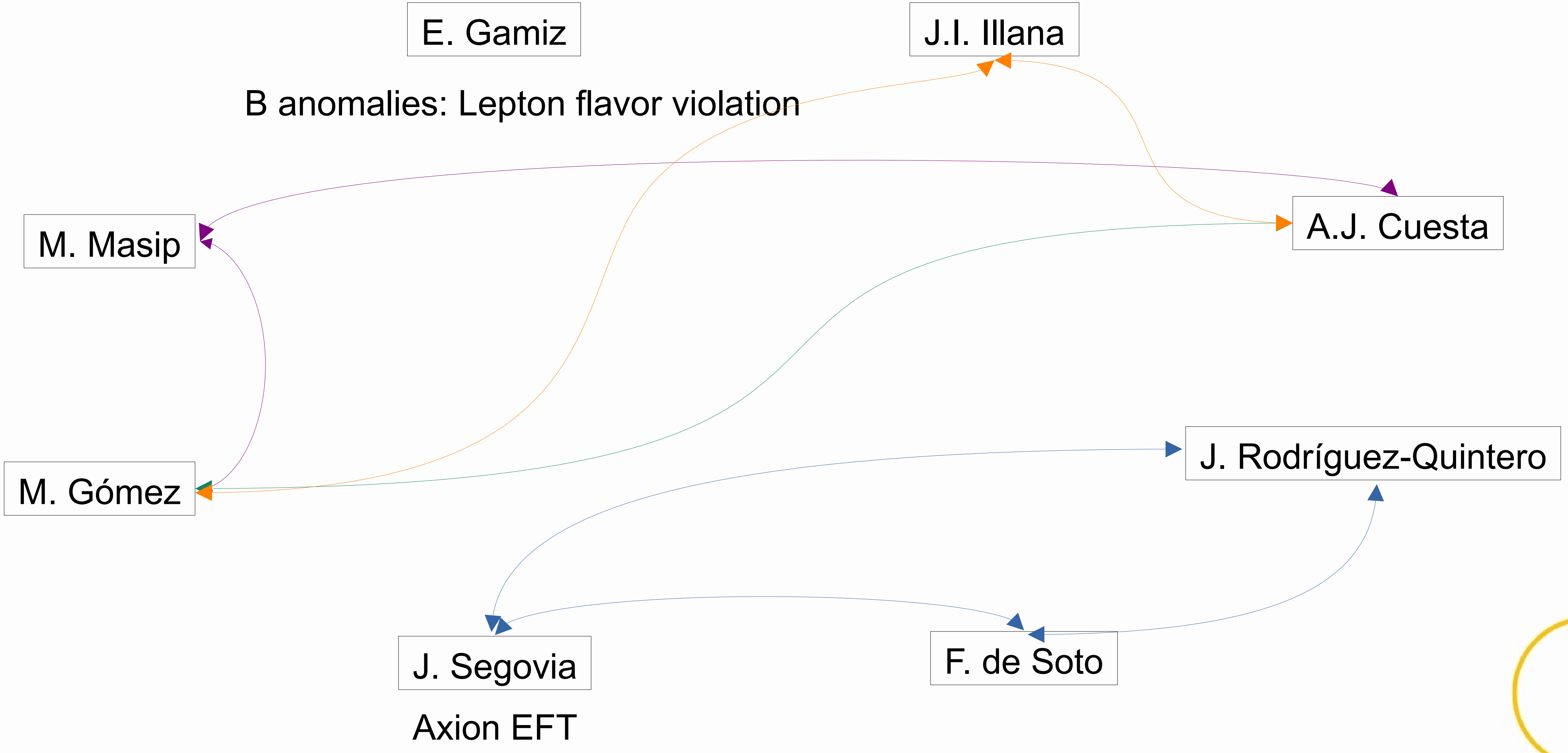

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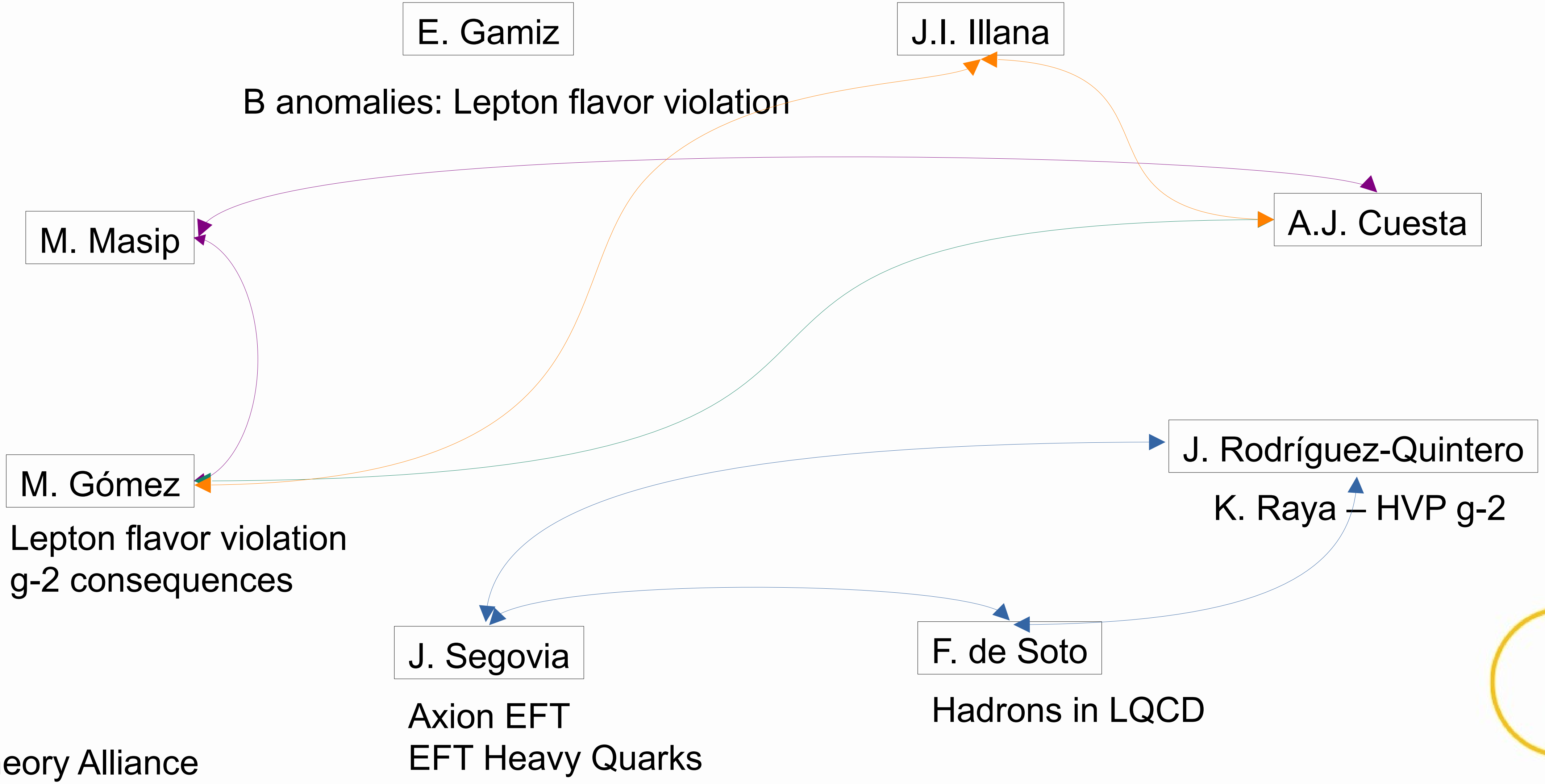
Past and current lines of research (LQCD)

- Calculation of light-light and heavy-light decay constants, semileptonic form factors and neutral meson mixing parameters with lattice QCD techniques.
- Hadronic-vacuum-polarization (HVP) contribution to $(g-2)_\mu$
- **Tools:** ChPT estimate of systematic errors (Finite-Volume, discretization ...) and determination of LECs, EFTs for heavy quarks...
- **Phenomenology**: applications to the study of
  - **CKM matrix**: unitarity and consistency tests. $|V_{us}|$, $|V_{cd,cs}|$, $|V_{ub}|$, $|V_{cb}|$, $|V_{td,ts}|$
  - $B-$meson rare decays/B anomalies/LFU observables: $B\to K(\pi)\mu^+\mu^-$, $B\to D\tau\nu$ or $B\to D^*\tau\nu$

Future and possible new lines (LQCD)

- Heavy-light and light-light **decay constants** with scale-setting based on M_Ω (pseudoscalar (ongoing), vector and tensor currents).
- Semileptonic FF for decays to pseudoscalar and vector (unstable) mesons with **relativistic action**: $B_{(s)}(D_{(s)})\to P\ell\nu(\ell^+\ell^-)$, $B\to K^*\mu^+\mu^-$, $B\to\phi\mu^+\mu^-$.
  Pheno: $|V_{ub}|$ and $|V_{cb}|$ (inclusive vs exclusive tensions, description of FF shape), BSM tests via rare decays (branching fractions, angular observables, LFU ratios), LFU tests, constrain Wilson coefficients C_9, C_{10}, $|V_{td(ts)}|$ ...
  Part of the program is ongoing
- Neutral meson mixing (K, D and B_s), including LD contributions. (**possible**)
- Reusing HVP $(g-2)_\mu$ correlators: $R=\frac{\sigma(e^+e^-\to\text{hadrons})}{\sigma(e^+e^-\to\mu^+\mu^-)}$, τ physics?, ...(**possible**)
- QED and SIB corrections to decay constants and sem. FF (longer term).

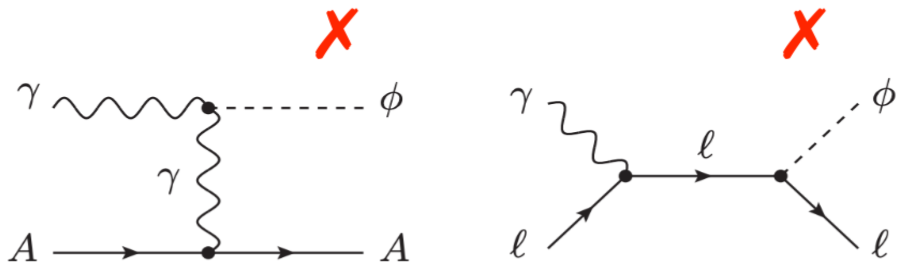
Potential synergies of the collaboration



Axion-like particles in the Early Universe: the majoron

Cosmology of an Axion-Like Majoron. A.J.Cuesta, J.I. Illana, M. Masip, M. Gómez
Journal of Cosmology and Astroparticle Physics 04 (2022) 009 [arXiv:2109.07336]

This mechanism can transfer energy from **photons** to this dark radiation, due to resonant production in the primordial magnetic field ($B \lesssim 1\mathrm{nG}$)



$$\overrightarrow{B}$$
$$\gamma \leftrightarrow \phi$$

✔

Our majoron has tiny couplings to charged leptons. Therefore, the **Primakoff and Compton production of majorons** is very inefficient

However, the presence of a primordial magnetic field can mediate **resonant production of majorons** in the primordial plasma **at a specific temperature (or range of temperatures)**

Bonus effect: since resonant production of majorons made some photons disappear (photons oscillating into majorons), **if this happened *after* BBN**, this would mean that **the actual baryon-to-photon ratio at BBN was smalller** than what is measured at recombination, in a way that is **consistent with the latest BBN deuterium observations.**

Potential synergies of the collaboration

E. Gamiz

J.I. Illana

B anomalies: Lepton flavor violation

Good connection between BSM physicists.
Other projects (?)

M. Masip

A.J. Cuesta

M. Gómez

Lepton flavor violation
g-2 consequences

J. Rodríguez-Quintero

K. Raya – HVP g-2

J. Segovia

Axion EFT
EFT Heavy Quarks

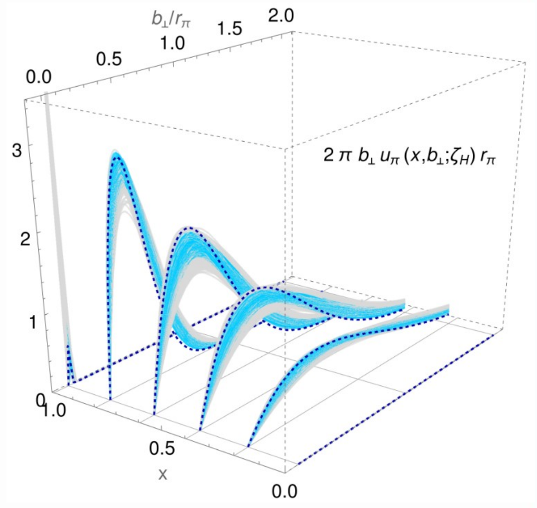
F. de Soto

Hadrons in LQCD

Meson Structure

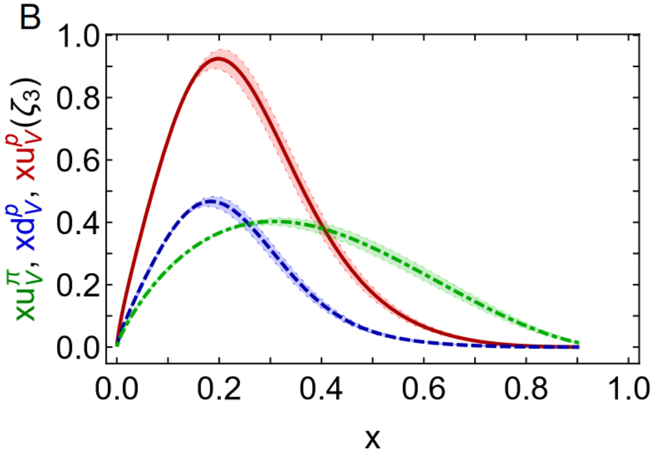
- 1-Dimensional images of Nambu-Goldstone bosons:
  - Distribution functions and amplitudes, electromagnetic and gravitational form factors, mass and pressures densities …

- 3-Dimensional images:
  - Light-front wave functions, generalized parton distributions, TMDs, …
  - Extension to heavier mesons and diquarks.
  - Study of rho → pi+gamma, K*→ K+gamma, D*→ D+gamma, B*→ B+gamma
  - QCD evolution based on the all-orders scheme and flavor splitting.
  - Applications to HEP: hadronic contributions to the muon g-2.



Baryon Structure

- Nucleon and Delta electromagnetic form factors:
  - → completing the SCI picture and beyond.
- First explorations on nucleon PDFs and other structure functions.
- QCD evolution and flavor splitting.



Potential synergies of the collaboration

E. Gamiz

J.I. Illana

B anomalies: Lepton flavor violation

Good connection between SM physicists.
Distributions to HEP (?)

M. Masip

A.J. Cuesta

M. Gómez

Lepton flavor violation
g-2 consequences

J. Rodríguez-Quintero

K. Raya – HVP g-2

J. Segovia

Axion EFT
EFT Heavy Quarks

F. de Soto

Hadrons in LQCD

Main Research Topic: Particle Physics Phenomenology.

Physics Beyond the Standard Model:

- Neutrino Physics : Neutrino flavor oscillations and their consequences.
- Lepton flavor violation: $\mu \rightarrow e\,\gamma$
- Anomalous Muon g-2. Mismatch between the experimental value and the SM prediction.

Supersymmetric Extension of the Standard Model:

- Grand Unified Models (GUT's): SO(10), SU(5), Pati-Salam.
- Dark Matter.
- LHC searches for SUSY particles.

Potential synergies of the collaboration

E. Gamiz

B anomalies: Lepton flavor violation

J.I. Illana

Is there a project on neutrino Physics?
(SM + BSM) physics

M. Masip

A.J. Cuesta

M. Gómez

Lepton flavor violation
g-2 consequences

J. Rodríguez-Quintero

K. Raya – HVP g-2

J. Segovia

Axion EFT
EFT Heavy Quarks

F. de Soto

Hadrons in LQCD

Lattice determination of QCD fundamental Green functions:

- Extensive analysis of three gluon vertex at any kinematics.

- Exploratory study of four gluon vertex in quenched-lQCD for particular kinematics.

- Lattice calculation of quark propagator (and quark-gluon vertex) with a physical pion mass.

Phenomenology of QCD fundamental Green functions:

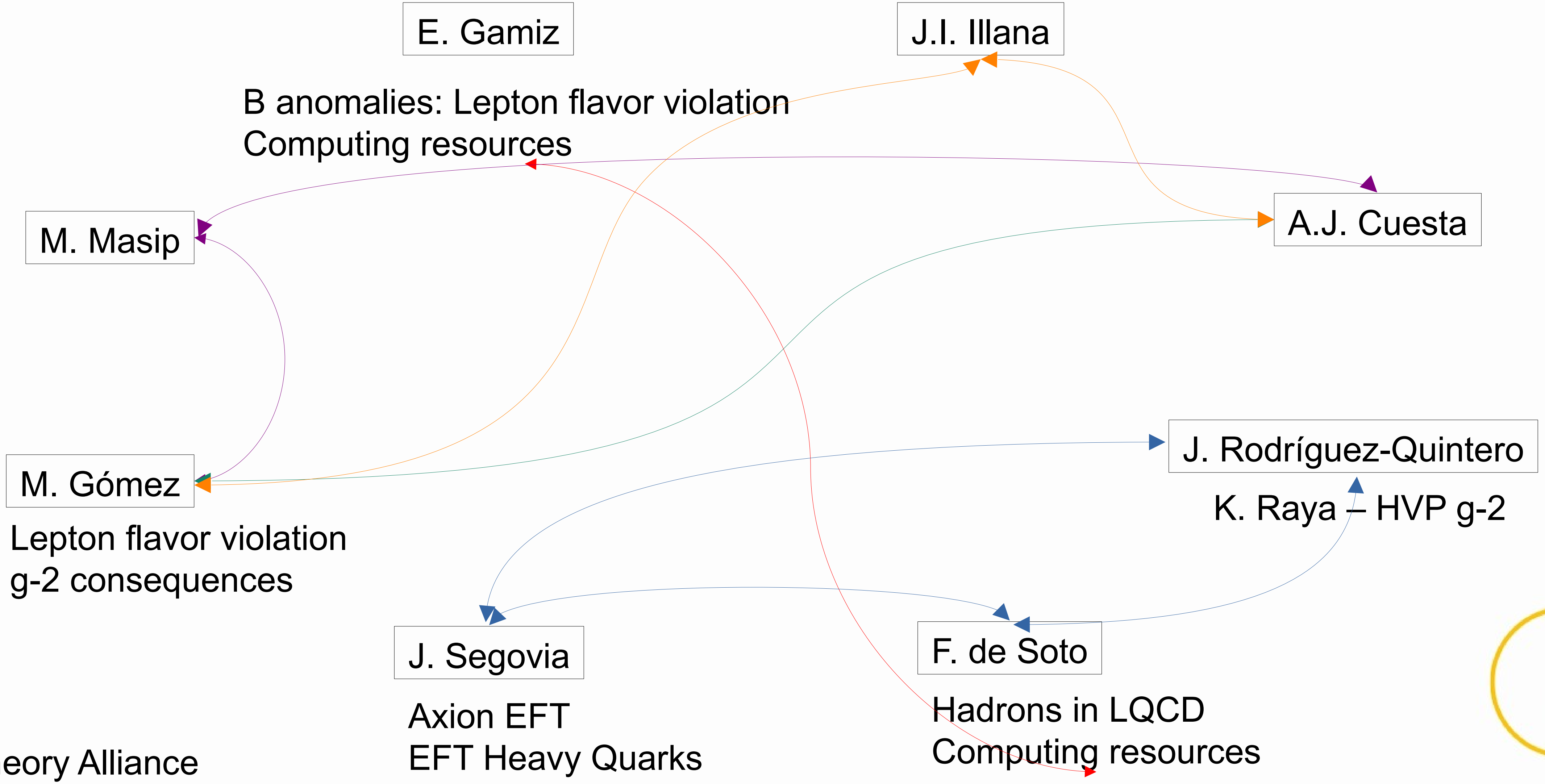
- Schwinger mechanism for gluon mass generation.

- Spectral analysis of quark propagator.

- DSE for the quark-gluon vertex with lattice inputs.

- Determination of alpha_s from general kinematics three gluon vertex?

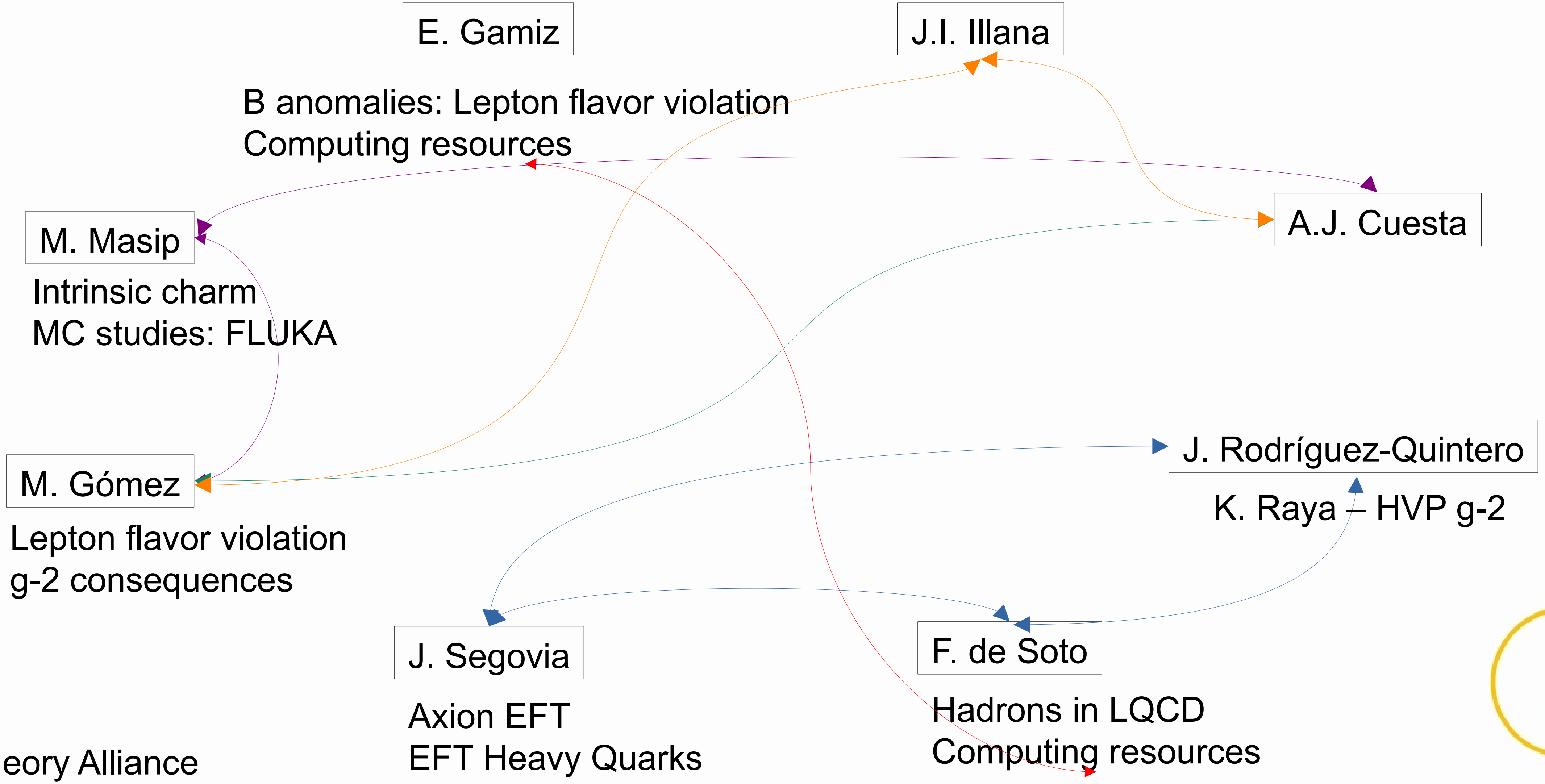
Potential synergies of the collaboration



Jorge Segovia

- **Past and present:**
  - Application of a chiral quark model (CQM) to study conventional hadrons: masses, wavefunctions, EM properties, strong and weak decays.
  - Extension of the Fock space covered by the naive CQM in order to describe multiquark systems and provide theoretical support to the XYZP discoveries.
  - Studies of hadrons in the light-quark sector using Schwinger-Dyson equations and covariant bound-state equations: masses, wavefunctions and distribution functions.
  - Application of nonrelativistic effective field theories such as NRQCD and pNRQCD to the study of heavy mesons: charmonium, bottomomium and heavy-quark hybrids.
- **Future:**
  - CQMs: Natural extension of our studies to the baryon and baryon-meson sectors. Hadrons with a constituent gluon content. Formulation of CQMs in the Light-front.
  - DSEs: There is a need of implementing the latest developments in QCD Green functions to the covariant bound state equations of mesons and baryons. - OGE+Chiral, - BSWF vs. LFWFs, - Distribution functions.
  - NR-EFTs: Axions, axion stars and BEC glumps. String effective theory + pNRQCD for higher excitations of conventional heavy mesons. Monte Carlo studies of many-body systems.

Potential synergies of the collaboration



Potential Synergies of the collaboration

- E. Gamiz: What is the status of R(D$^{(*)}$) for looking at new physics. There are other ratios such as R(J/\Psi).

- E. Gamiz: In the muon g-2 problem, there was a lattice paper which claims that a particular correction brings the experimental and theoretical value in agreement. BMW Colloboration.

- M. Masip: Previous work on flavor physics, model building and cosmic ray physics could be useful in topics like intrinsic charm and bottom or forward physics in extensive air showers. ANNs (j. Rojo) applied to astroparticle physics. The neural network approach to determine the atmosferic neutrino flux from experimental data on neutrino event rates.

- P.G. Ortega (USAL): uses the general purpose Monte Carlo transport code FLUKA (PITHYA) able to analyzes the transport of any particle into any material with a friendly interface in order to define physics.

- PARTONS: What is the best way of participating in such a project? What is Pietro doing? ANNs?

Potential Synergies of the collaboration

[...]