open
forcefield

@openforcefield

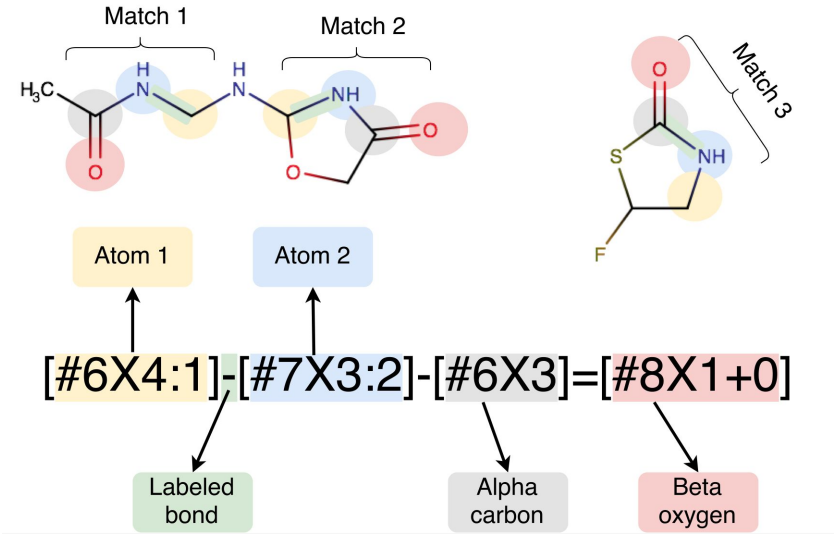
www.openforcefield.org

Open Force Field Consortium

Summer 2023

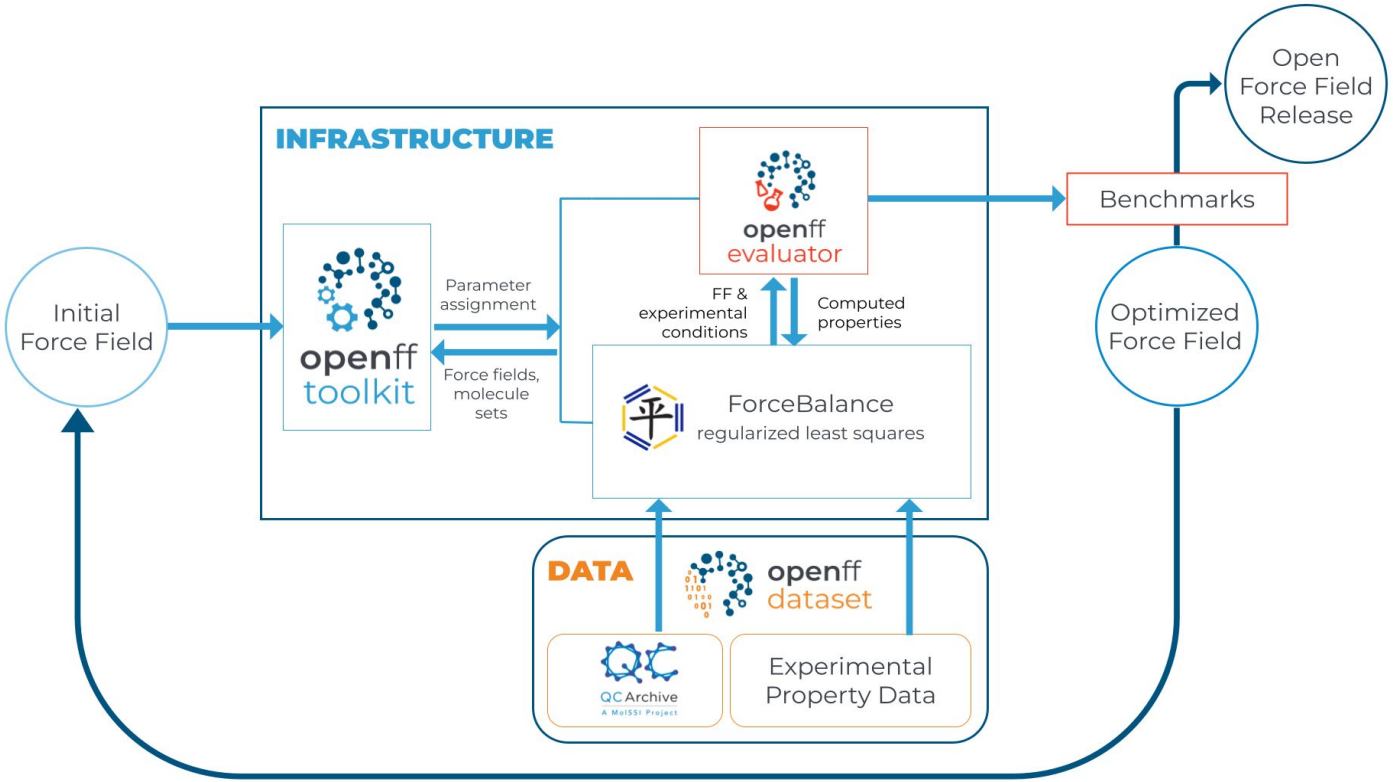
Our mission

Using
data-driven,
automated,
systematic
techniques to build the next generation of
small-molecule and
biomolecular force fields



Use of industry-standard SMARTS/SMIRKS chemical perception greatly simplifies tooling for parameter assignment while solving issues with extensibility and flexibility

What we do


Open
Force Field
Release
INFRASTRUCTURE
openff
evaluator
Benchmarks
Initial
Force Field
openff
toolkit
Parameter
assignment
Force fields,
molecule
sets
FF &
experimental
conditions
Computed
properties
ForceBalance
regularized least squares
Optimized
Force Field
DATA
openff
dataset
QC Archive
A MolSSI Project
Experimental
Property Data

Our mission

OPEN SOFTWARE

Automated infrastructure enables rapid experimentation with minimum human intervention

OPEN DATA

Access to large, high quality experimental and quantum chemical data facilities easy curation of balanced train / test sets

OPEN SCIENCE

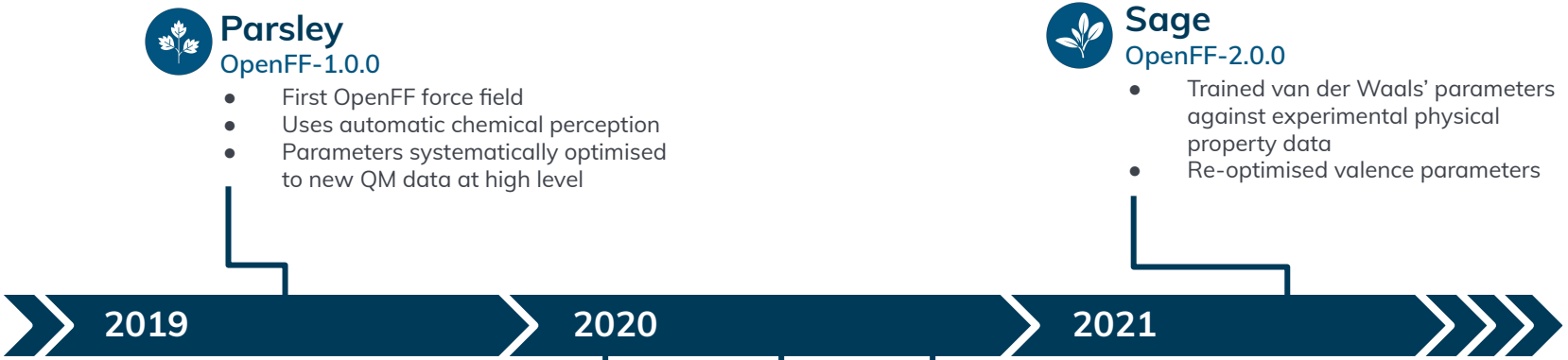
Exploring new force field science:

hypothesis - build software - train - test - iterate

is now almost routine

Force field roadmap

Open Force Field



Parsley
OpenFF-1.0.0

- First OpenFF force field
- Uses automatic chemical perception
- Parameters systematically optimised to new QM data at high level

Sage
OpenFF-2.0.0

- Trained van der Waals' parameters against experimental physical property data
- Re-optimised valence parameters

Parsley
OpenFF-1.1.0

- New valence parameter terms

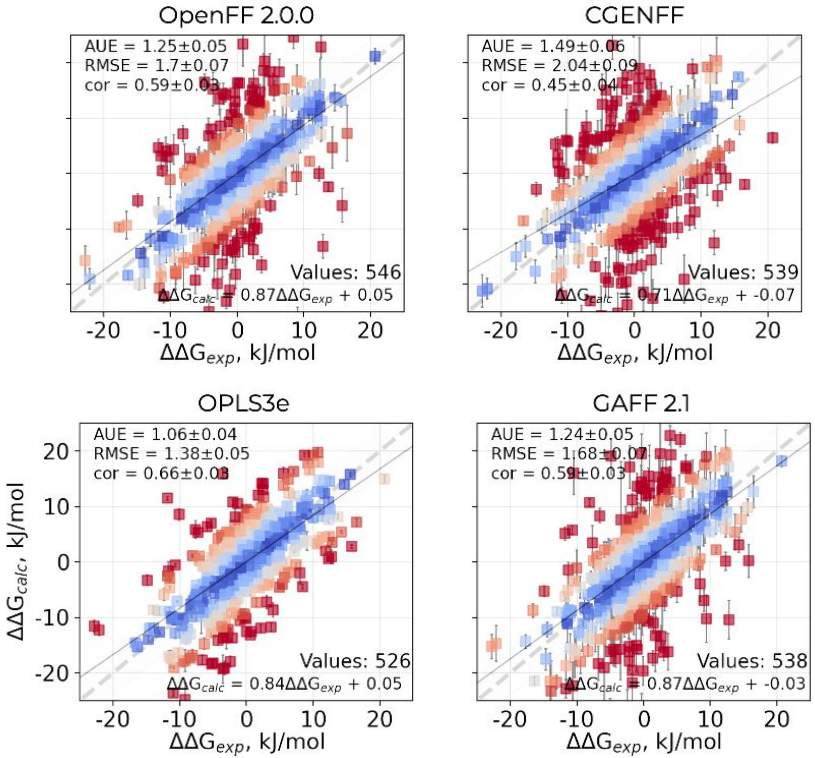
Parsley
OpenFF-1.2.0

- Expanded QM data with greater chemical diversity
- Improved phosphate geometries

Parsley
OpenFF-1.3.0

- Improved amide geometries and torsions

OpenFF force fields are competitive



OpenFF 2.0.0 (Sage) outperforms other public small molecule force fields

Gapsys V, Hahn DF, Tresadern G, Mobley DL, Rampp M, de Groot BL. Pre-Exascale Computing of Protein-Ligand Binding Free Energies with Open Source Software for Drug Design. J Chem Inf Model. **2022**, 62(5):1172-1177. doi: 10.1021/acs.jcim.1c01445

Boothroyd S, Behara PK, Madin O, Hahn D, Jang H, Gapsys V, et al. Development and Benchmarking of Open Force Field 2.0.0 — the Sage Small Molecule Force Field. ChemRxiv. Cambridge: Cambridge Open Engage; 2023. (Preprint)

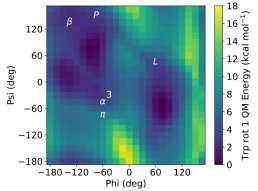
Force field roadmap

Open Force Field

Rosemary (template charges)

OpenFF-3.0.0

- Self-consistent force field for biopolymers and small molecules
- Incorporating protein-specific torsions
- Benchmarked against QM and physical property data
- Includes template partial charges for standard residues



Thyme

OpenFF-4.0.0

- Re-optimized BCCs to HF/6-31G* (or higher) electric field
- Virtual sites fit to HF/6-31G* (or higher) electric field

2023

Sage minor release

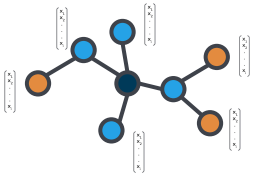
OpenFF-2.1.0 (released May)

- New training targets
- Broader parameter coverage
- New parameters
- Targeted improvements for specific functional groups, e.g. sulfonamides

Rosemary (Graph charges)

OpenFF-3.1.0

- Use convolutional graph neural networks (CGNNs) to generate AM1-BCC-like charges
- Charges are fast and conformer-independent
- Enables custom macromolecule support



Future research directions

Promising future directions or ongoing research

- Automated parameter generation by chemical perception
- Surrogate modelling to escape local minima with global optimisation
- Improper torsions with interpolation by Wiberg Bond Order
- Internal coordinate hessian fitting
- Enumerating explicit torsion multiplicities
- Re-fitting water models
- Polarizability

WE NEED YOUR HELP

- **Consortium membership** (Tier 1, 2, 3)
  - **Financial contribution**
  - **Or in-kind contribution** via supporting a postdoctoral (or similar) position at the company such that at least 50% of time is dedicated to OpenFF efforts
- **Membership carries various benefits** including official benefits on the next slide, plus:
  - Involvement in our community; opportunity for pre-competitive collaboration with industry and OpenFF scientists (e.g. code can be exchanged under permissive license within scope of agreement)
  - Join our science teams and give advice/help us prioritize what's important for your organization; help us ensure our FFs treat your chemistries accurately
  - Ensuring you have ongoing access to state-of-the-art force fields you can deploy freely at any scale you like without licensing requirements
- **Participation of the company scientists in Advisory Board** calls and in-person meetings to ensure that OpenFF is adequately addressing your scientific and technical needs

MEMBERSHIP BENEFITS

Sustaining Partner (Tier 1): A Sustaining Partner contributes a **minimum** of $100,000 annually or equivalent in-kind support.

Sustaining Partners will receive all Supporting Partner benefits, PLUS:

- Priority in recommending regions of chemical space or molecular fragments
- Priority in technical support and scientific consultation from the project's software engineer or other project members.
- At least one Sustaining Partner will serve on the Governing Board at all times (selected by the Advisory Board as detailed in the Bylaws, Annex II) provided at least one Partner contributes at this level.

Supporting Partner (Tier 2): A Supporting Partner contributes a **minimum** of $50,000 annually or equivalent in-kind support.

Supporting Partners will receive all Facilitating Partner benefits, PLUS:

- The ability to recommend regions of chemical space or molecular fragments to be prioritized
- Technical support and scientific consultation from the project's software engineer or other project members
- Representation on the Advisory Board and eligibility for election to the Governing Board
- Direct support channels for priority issues or reporting critical failures that need immediate attention.

Facilitating Partner (Tier 3): A Facilitating Partner contributes a **minimum** of $20,000 annually or equivalent in-kind support

Facilitating Partner benefits include:

- Regular progress updates and inside knowledge of project progress as detailed in the Open Force Field Consortium Bylaws
- Public credit, such as through approved use of logos, co-authorship of publications
- Irrevocable license to software, data, and force fields generated by the Consortium, as detailed in Article 3

In-kind Support: In-kind support, such as provision of personnel to work on the project, is valued at 80% of the approximate monetary value of the provided resources if they were provided for directly. Only provision of personnel spending > 50% of the individual's effort directed by the Governing Board counts towards in-kind support via this mechanism.