

How to calculate Fermi-Softness *via* VASP

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FEB 2022



Contents

1. How to **install program** ?
2. How to **run VASP program** for calculating Fermi-Softness ?
3. How to **get Total, Condensed and Local Fermi-Softness** ?
4. How to **visualize Local Fermi-Softness** ?

1. Install program

Anaconda3, vaspkit, bader, and FermiSoftness is necessary.

1. You can install **Anaconda3** from the website:

[Anaconda | Individual Edition \(https://www.anaconda.com/products/individual#Downloads\)](https://www.anaconda.com/products/individual#Downloads)

2. You can install **vaspkit** from the website:

[Installation — vaspkit documentation \(https://vaspkit.com/installation.html\)](https://vaspkit.com/installation.html)

3. You can download **bader** from the website:

[Bader Charge \(http://theory.cm.utexas.edu/henkelman/code/bader/\)](http://theory.cm.utexas.edu/henkelman/code/bader/)

4. You can install **FermiSoftness** by pip, ASE and Numpy will be installed automatically:

```
$ pip install FermiSoftness
```

2. Run VASP program

Usually, the process of calculating Fermi-Softness is the same as calculating density-of-state (DOS):

1. Build a Slab model.
2. Relaxation calculation.
3. Static calculation (SCF) with small k-points.
4. Static calculation (non-SCF) with **large k-points**, reading CHGCAR generated by SCF.

3. Calculate Total, Condensed and Local Fermi-Softness

1. Generate input file runfs.py :

```
$ python -c "from FermiSoftness import gen; gen(software='vasp');"
```

2. Copy runfs.py to the path where the non-SCF output of VASP is.

3. Calculate Total, Condensed and Local Fermi-Softness

3. Modify the parameters in runfs.py :

```
kbT=0.4           # Electron temperature (eV)
dfdd_threshold=0.001 # Derivation of Fermi-Dirac distribution threshold
intermediate_file_options=False # Save intermediate files?
bader_dir='bader' # Path of bader
vaspkit_dir='vaspkit' # Path of vaspkit
band_gap={'VBM':[0.0], # If band gap exists, set as  $E_{\text{VBM}}, E_{\text{CBM}}$  (Do not minus  $E_{\text{Fermi}}$ );
          'CBM':[0.0]} # Otherwise set as 0.0 0.0 (eV)
```

- Save intermediate files can make calculation become faster sometime, but need more disk space
- If **bader** and **vaspkit** are in your $\$PATH$, you don't need to change **bader_dir** and **vaspkit_dir**

3. Calculate Total, Condensed and Local Fermi-Softness

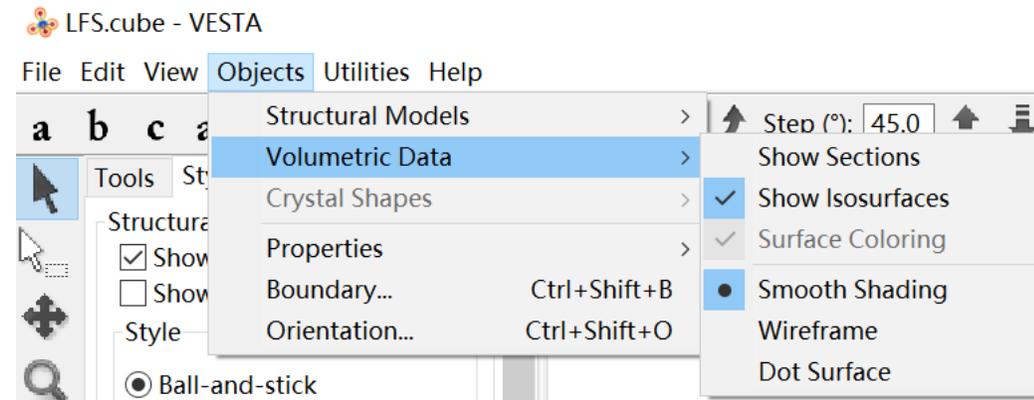
4. Run `python runfs.py` in terminal.
5. Wait ... it will take several minutes.
6. Finished. You can find files FSCAR and LFS.cube in current path. (If the wavefunction is spin polarization, you can find `_UP`, `_DW` for different spin. If band gap exists, you can find `_CB`, `_VB` for holes and electrons.)
7. In FSCAR, you can find Total Fermi-Softness (NUMBER OF ELECTRONS) and Condensed Fermi-Softness (CHARGE), the grid data of Local Fermi-Softness were recorded in LFS.cube.

4. Visualize Local Fermi-Softness

1. Isosurfaces

Load LFS.cube by VESTA

- Objects->Volumetric Data-> Show Isosurfaces



4. Visualize Local Fermi-Softness

1. Isosurfaces

Objects->Properties-> Isosurfaces

- Set appropriate isosurface level

Properties - LFS.cube ×

General Atoms Bonds Polyhedra **Isosurfaces** Sections

Material

Specular: 0 0 0  Shininess (%): 100

Isosurfaces

F(min) = 1.79487e-009; F(max) = 0.00412769;

Render from front to back

Positive  Opacity 1 (0~255): 127

Isosurface level: 0.0005 Opacity 2 (0~255): 255

Color: 255 255 0 

No.	level	mode	color
1	0.0005	Positive	

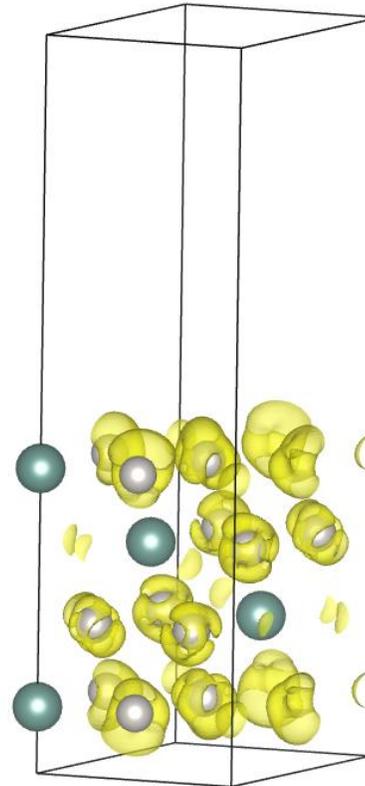
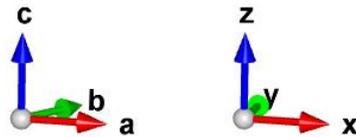
New
Delete

4. Visualize Local Fermi-Softness

1. Isosurfaces

Local Fermi-Softness mainly distributes on

Pt atoms in $\text{Pt}_3\text{Y}(111)$ surface.



4. Visualize Local Fermi-Softness

2. Contour plante

Load LFS.cube by VESTA

Edit->Lattice Planes

- Set Miller indices (001)
- Set appropriate Distance from origin

Lattice Planes - LFS.cube

Phase: 1 Fermi_Softness

Material

Specular: 255 255 255 Shininess (%): 100

Edges

Show edges Line width: 1.0

Add lattice planes

Miller indices (hkl): 0 0 1

Distance from origin: 9.85863 Å (0.445004 x d)

Color (RGBA): 255 0 255 192

Calculate the best plane for the selected atoms

No.	h	k	l	d (Å)
1	0	0	1	9.85863

New Delete Clear

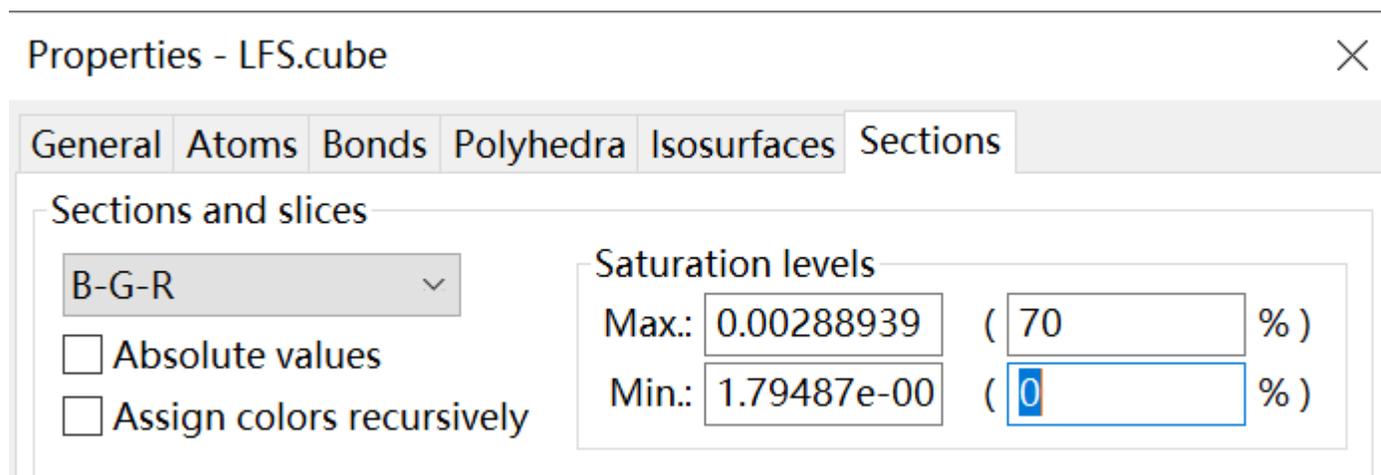
< > ↑ ↓

4. Visualize Local Fermi-Softness

2. Contour plane

Objects->Properties-> Sections

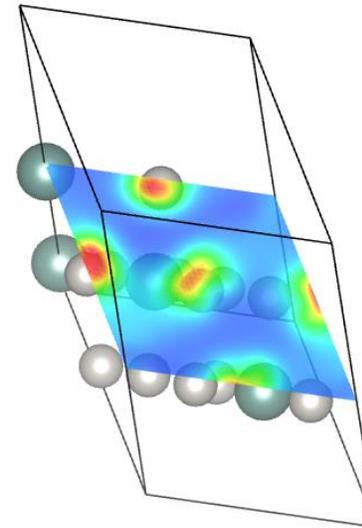
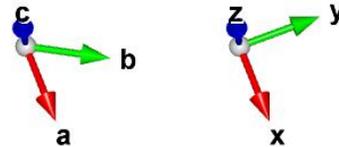
- Set appropriate Saturation level



4. Visualize Local Fermi-Softness

2. Contour plane

Local Fermi-Softness mainly distributes on
Pt atoms in $\text{Pt}_3\text{Y}(111)$ surface.

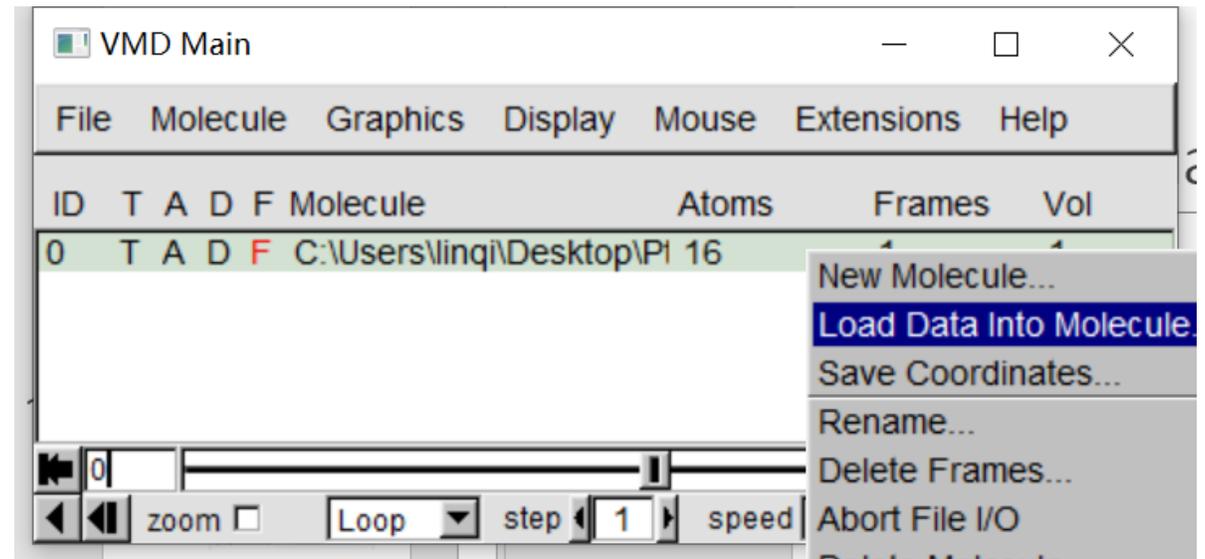


4. Visualize Local Fermi-Softness

3. Projected isosurface

Load CHGCAR by VMD

Load Data Into Molecule: LFS.cube



4. Visualize Local Fermi-Softness

3. Projected isosurface

Graphics->Colors->Color Scale->Method: BWR

Graphics->Representation

- Make first Rep: CPK Name all
- Make second Rep: Isosurface Volume 1

Graphics->Representation->Trajectory

- Set appropriate Color Scale Data Range

Style	Color	Selection
CPK	Name	all
Isosurface	Volume 1	<volume>

Selected Atoms: all

Draw style | Selections | Trajectory | Periodic

Coloring Method: Volume | 1: C | Material: Opaque

Drawing Method: Isosurface | Default

Range: $1e-007$ | 72804 | Vol: vol0: CHGCAR

Isovalue: 0.0276

Step: 1 | Draw: Wireframe

Size: 1 | Show: Box+Isosurface

4. Visualize Local Fermi-Softness

3. Projected isosurface

Local Fermi-Softness mainly distributes on Pt atoms in $\text{Pt}_3\text{Y}(111)$ surface.

