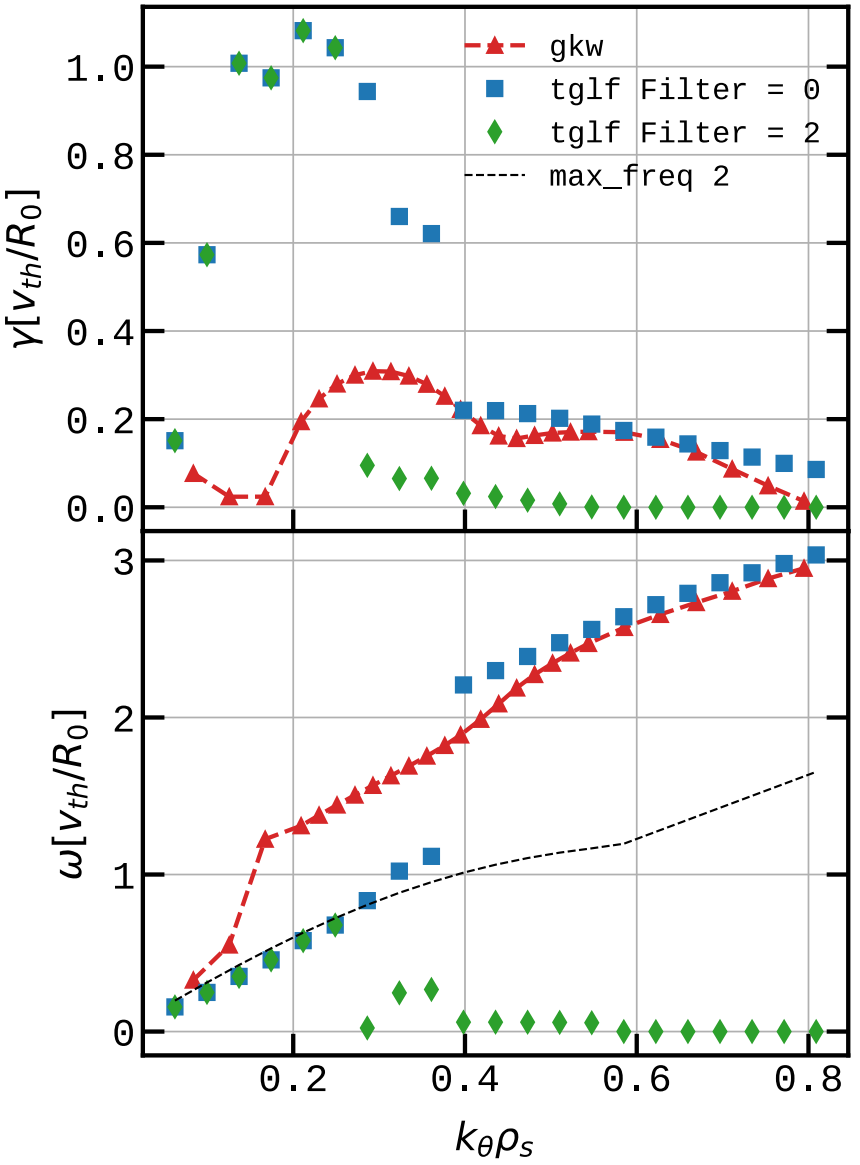
TGLF Filter Adapted to KBMs

Anass Najlaoui

Need for an adapted filter

- **The new filter needs to:**
  - **Filter spurious modes**
  - **But Keep the KBMs**

Max_freq = Filter*drift wave freq



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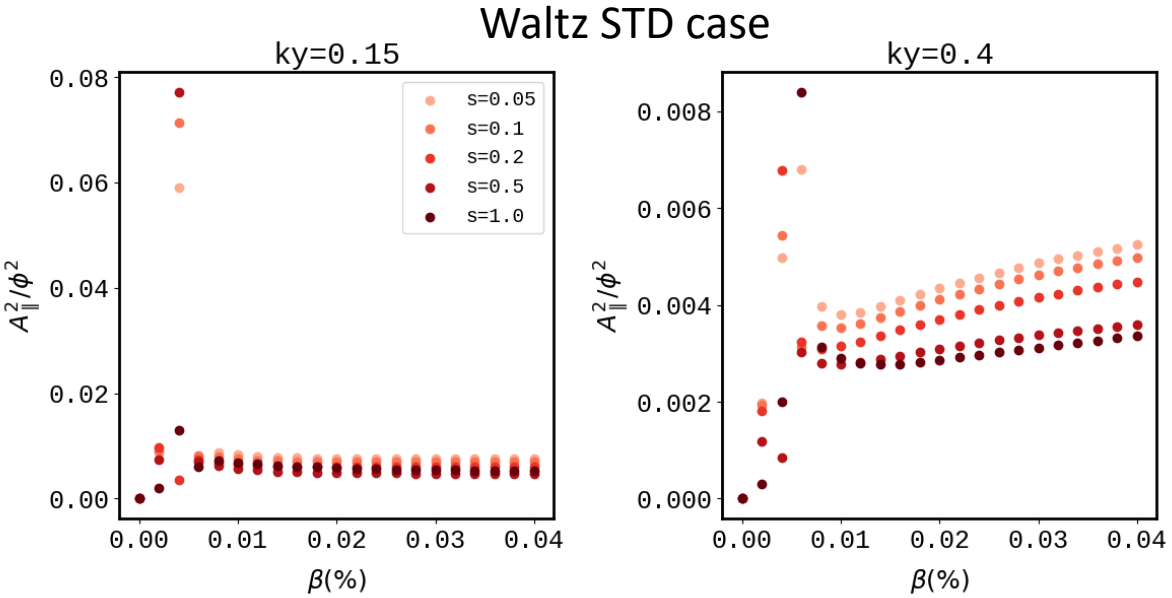
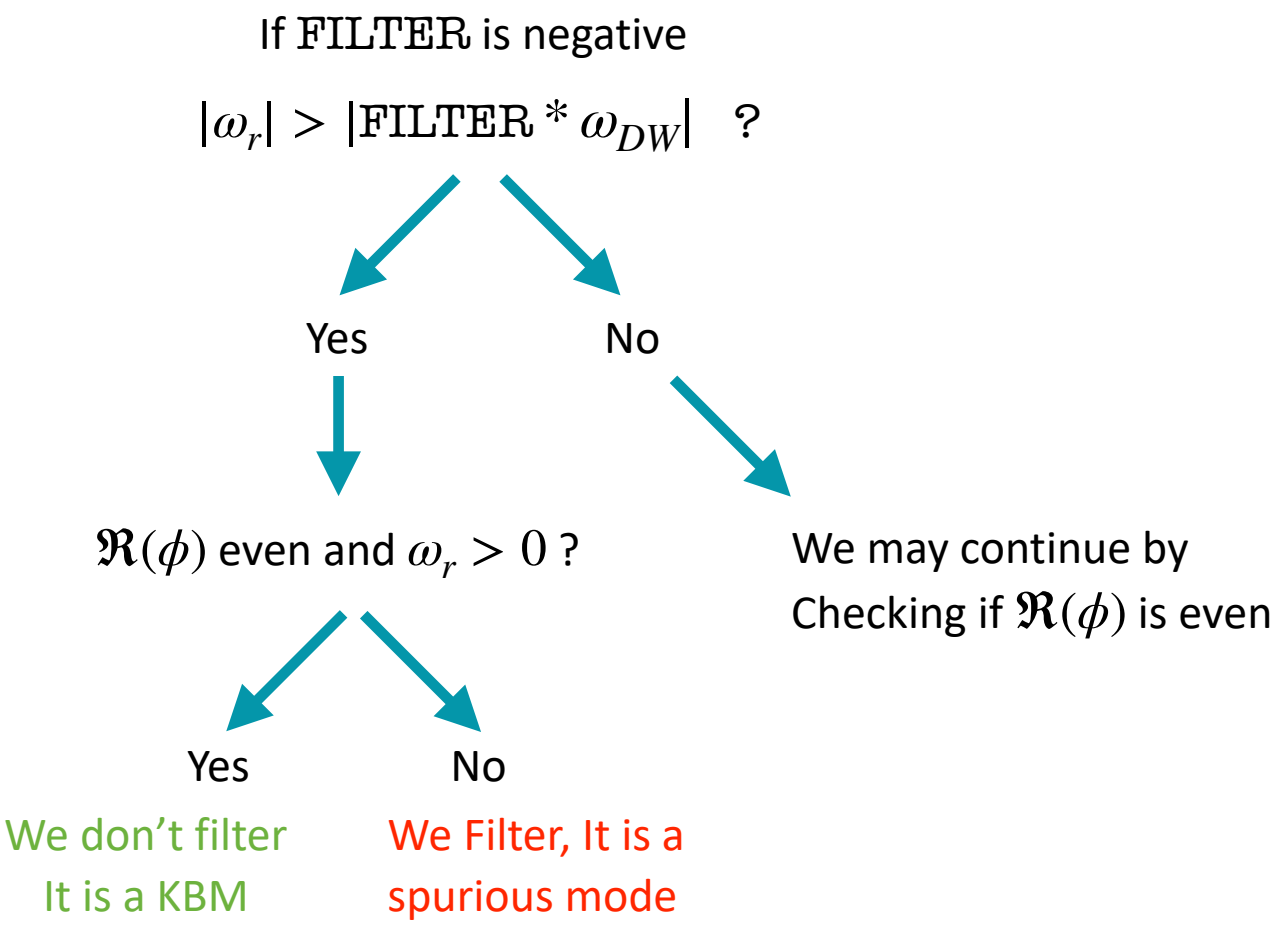
- **The suggested way was to identify the electromagnetic nature of the mode looking at the ratio** $A_{\|}^2/\phi^2$



There is not a clear distinction to evaluate the electromagnetic nature of modes

Instead of checking electromagnetic nature, we check the parity

- **Based on the observations that TGLF modes modeling KBMs are <u>even</u> and that spurious modes are <u>odd</u>, we can filter only spurious mode by doing:**



Effect of the new filter

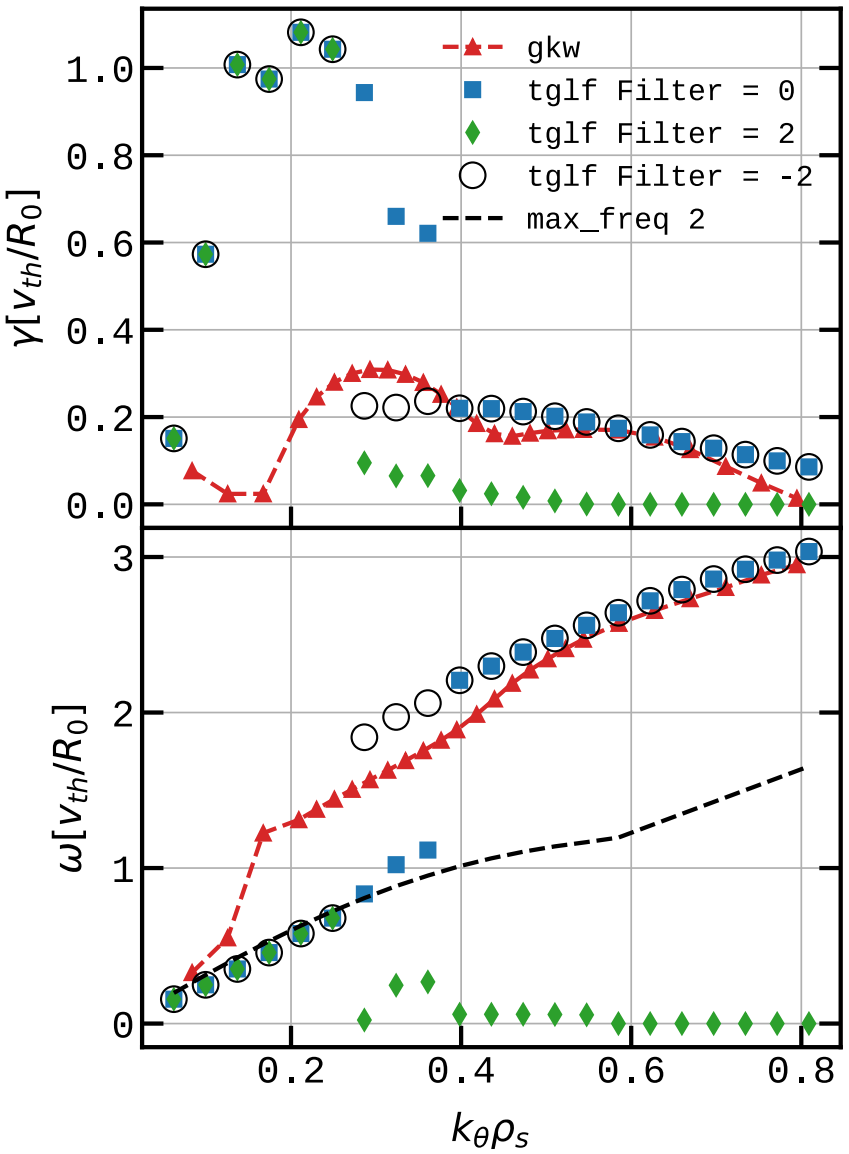
If FILTER is negative

$$|\omega_r| > |\mathrm{FILTER} * \omega_{DW}| \quad ?$$

Yes → $\Re(\phi)$ even and $\omega_r > 0$?

- Yes → It is a KBM
- No → We Filter

No



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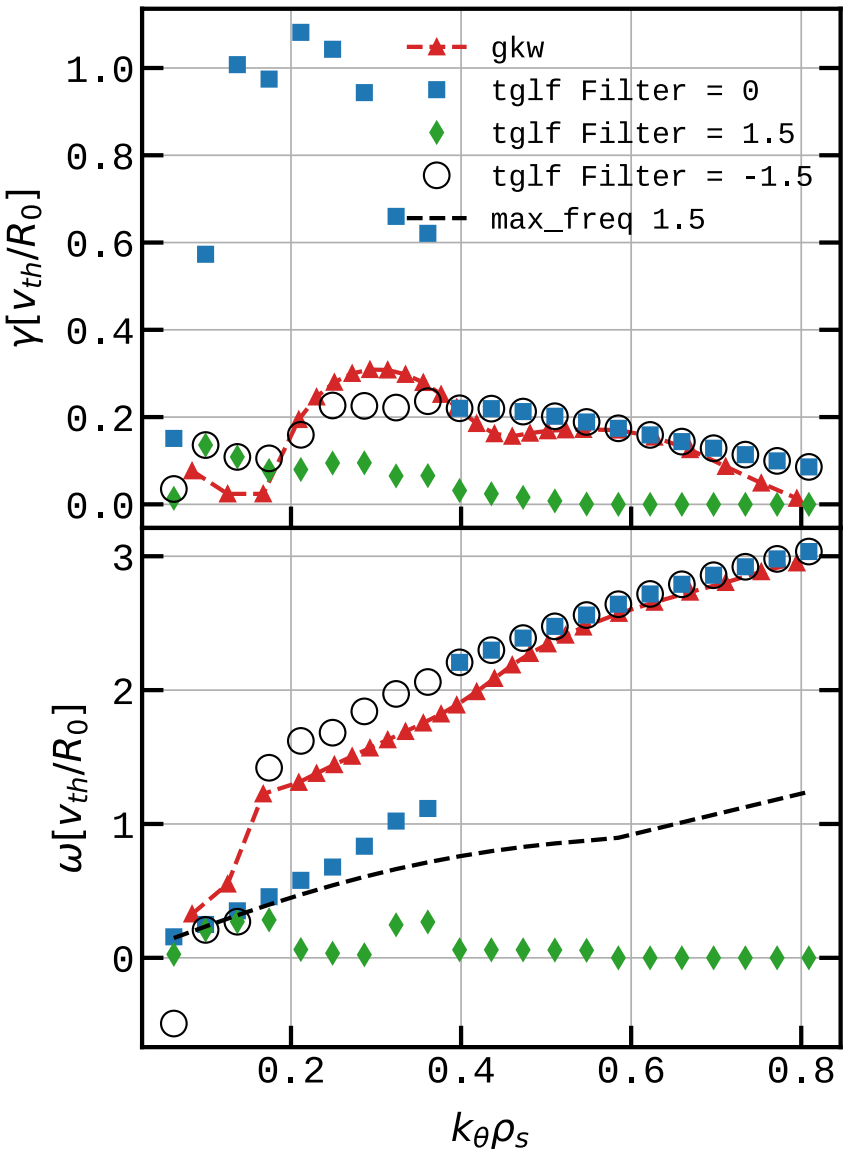


Effect of the new filter

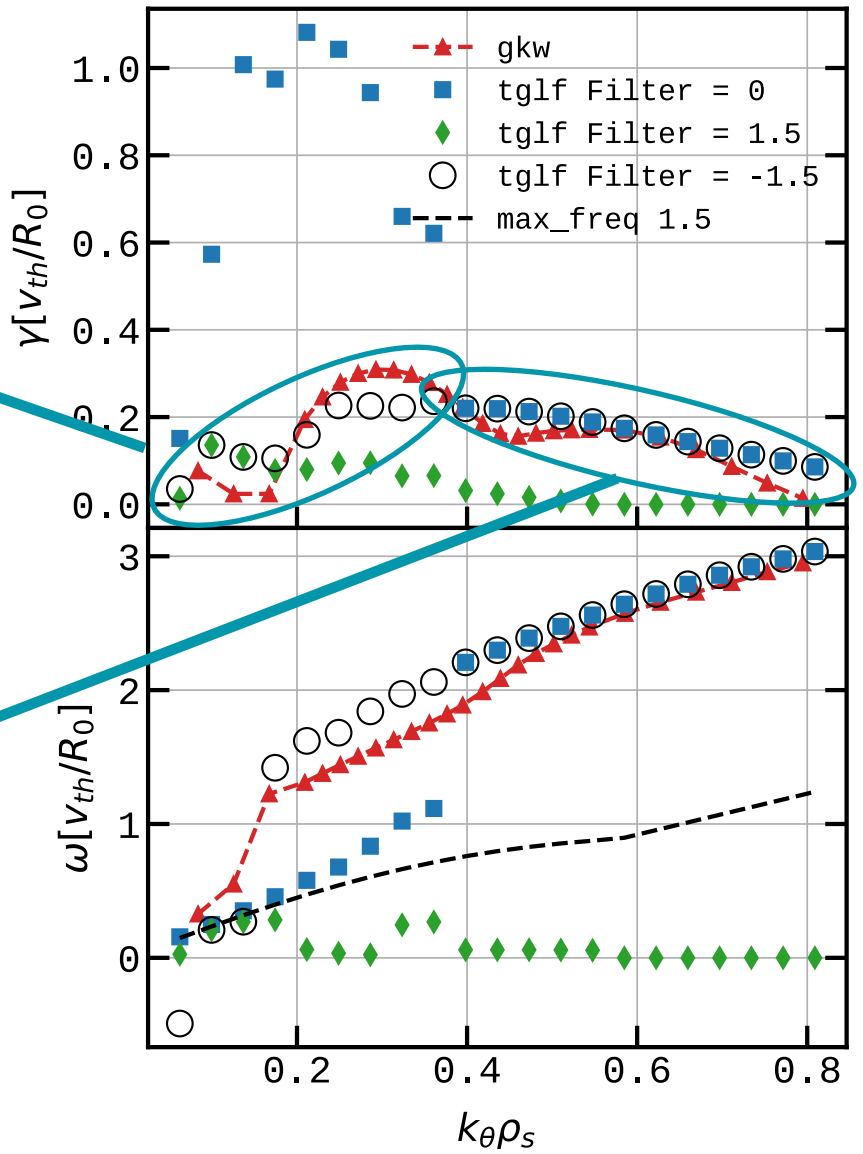
Filtered because $\omega_r >$ max_freq

But $\Re(\phi)$ not even

Not filtered because $\omega_r >$ max_freq

But $\Re(\phi)$ is even (KBM)

Test it in other cases

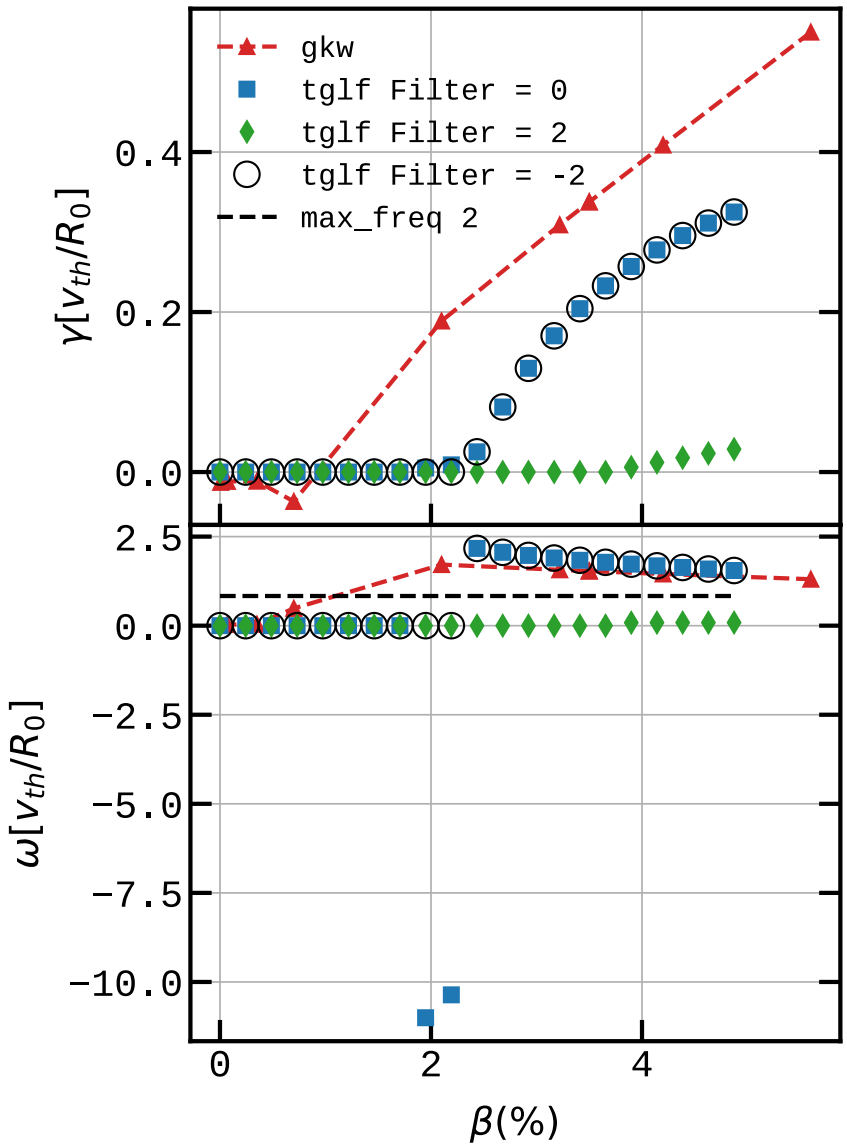


Test on different cases

JET 75225 Discharge at $\rho = 0.15$

R/L_{Ti}	R/L_{Te}	R/L_{Tc}	R/L_{Ni}	R/L_{Ne}	R/L_{Nc}	$\hat{s}$
4.2	2	4.2	1.67	1.5	-0.7	**0.05**
T_i/T_e	T_c/T_e	n_i/n_e	n_c/n_e	$\beta(\%)$	u	q
1.43	1.43	0.93	0.01	3.2	0.38	1.1

Spurious modes with $\omega_r > 2 * \omega_{DW}$ are filtered, but not KBMs

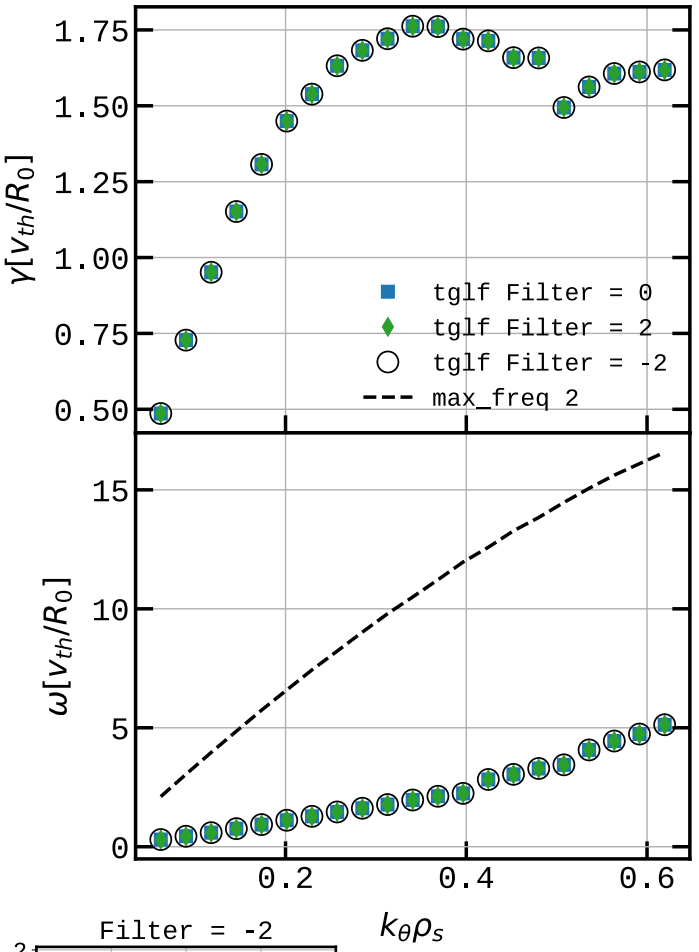


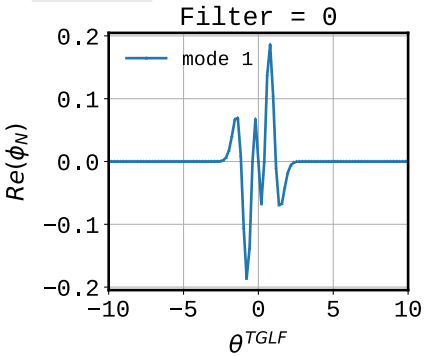
Test on different cases

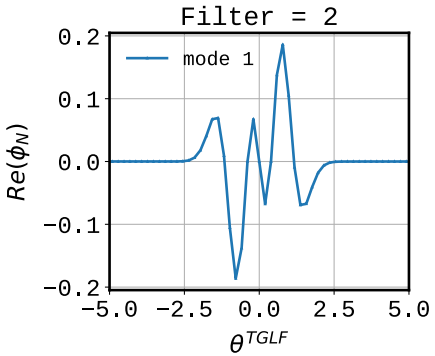
Steep-gradient regions

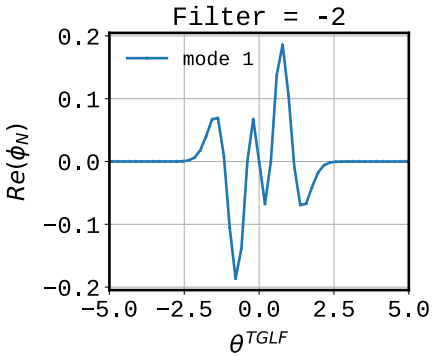
[M J Pueschel *et al* 2019 *Plasma Phys. Control. Fusion* **61** 034002]

$$R/L_{T_i} = 60$$
$$R/L_{T_e} = R/L_N = 0$$
$$\beta = 0.1\,\%$$
$$\hat{s} = 1$$





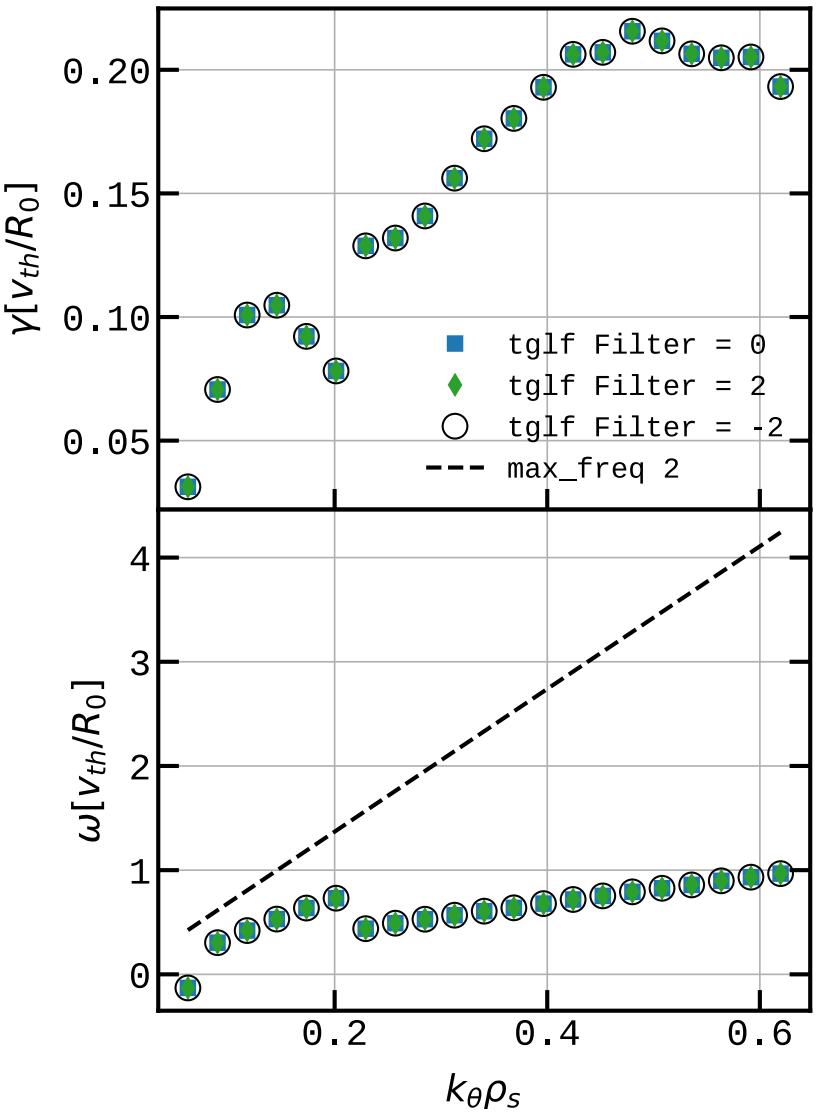




$$k_\theta\rho_s = 0.6$$

Test on different cases

Waltz STD case at High shear ($\hat{s} = 3$)



How the filter works in details

- **The basis Hermite functions Ψ_n are defined as:**

$$\Psi_n = e^{-\hat{\theta}^2/2} h_n \qquad \textbf{with} \qquad h_n = \hat{\theta}\sqrt{\frac{2}{n-1}}h_{n-1} - \sqrt{\frac{n-2}{n-1}}h_{n-2}$$

With $h_1(\hat{\theta}) = 1, \quad h_2(\hat{\theta}) = 2\hat{\theta}, \quad h_3(\hat{\theta}) = 4\hat{\theta}^2 - 2, \quad h_4(\hat{\theta}) = 8\hat{\theta}^3 - 12\hat{\theta}$ **etc…**

We notice that: $\Psi_n = e^{-\hat{\theta}^2/2} * h_n$

$e^{-\hat{\theta}^2/2}$ → Even

h_n → Even if n is odd, Odd if n is even

So we can build a function ϕ_{test} that can have the same parity as $\phi(\theta)$

We can build ϕ_{test} using only the `field_weight_QL_out` coefficients coupled with a Cos/Sin function (To mimic the parity of h_n without having to calculate it)

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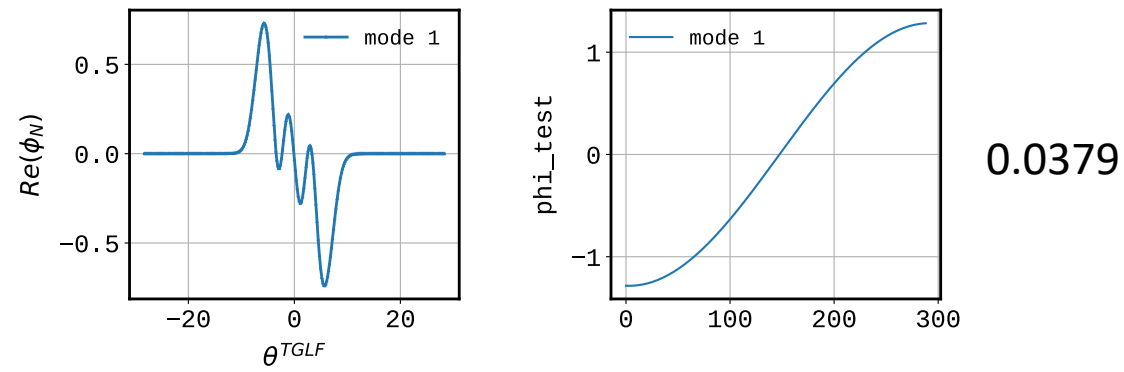
We can build ϕ_{test} using only the `field_weight_QL_out` coefficients coupled with a Cos/Sin function (To mimic the parity of h_n without having to calculate it)



0.0379

0.9989

I compute the ratio $\frac{|\sum \phi|}{\sum |\phi|}$

If > 0.9 then it is even
If < 0.1 then it is odd

Additional questions on the Filter

- **What to do when $|\omega_r| < |\mathrm{FILTER} * \omega_{DW}|$, But we have an odd mode parity or $\gamma >> \omega_r$?**

  We let it like that

- **Do the filter need to be run after of during the search of** `Width` **with** `Nbasis_min` **?**

  During the search of width

-

If FILTER is negative

$|\omega_r| > |\mathrm{FILTER} * \omega_{DW}|$?

Yes

$\Re(\phi)$ even and $\omega_r > 0$?

Yes

We don't filter

It is a KBM

No

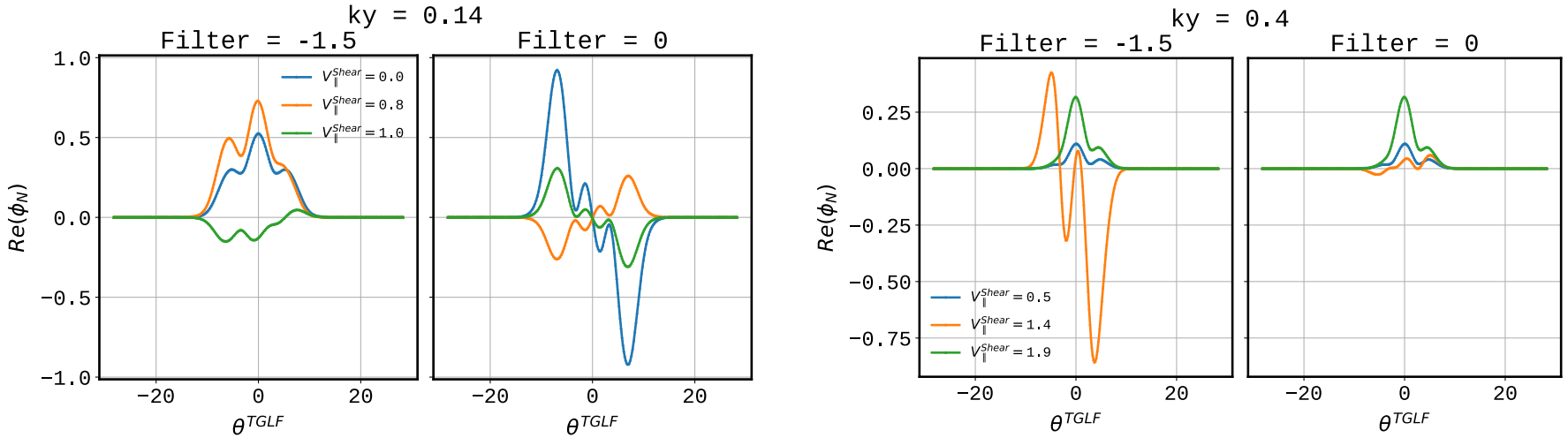
We Filter, It is a spurious mode

No

We may continue by Checking if $\Re(\phi)$ is even

Effect of the parallel velocity shear

- Increasing the parallel velocity shear can cause a shift in the mode structures, resulting in an uneven real part of the electrostatic potential.
- Is the condition $\frac{|\sum \phi|}{\sum |\phi|} > 0.9$ still valid for those modes? The answer is Yes, except in very rare cases where the mode structure becomes very uneven. However, in these rare instances, the ratio $\frac{|\sum \phi|}{\sum |\phi|}$ is around 0.5, so there is no need to adjust the threshold.
- Out of 441 test cases (varying ky from 0.05 to 0.65 in 21 steps and parallel velocity shear from 0 to 2 in 21 steps), only 5 cases were not recognized as KBMs by the filter and were excluded, similar to the results with the original filter. (One is represented here for $k_y = 0.4$ and $V_{\parallel}^{Shear} = 1.4$)



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Thank you for your attention

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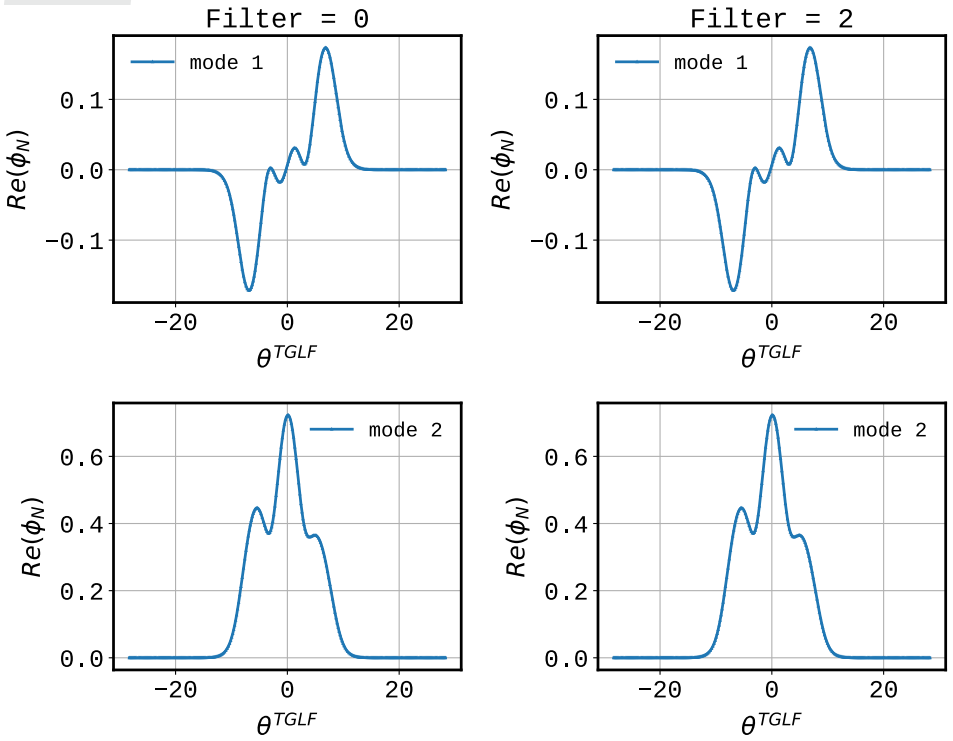
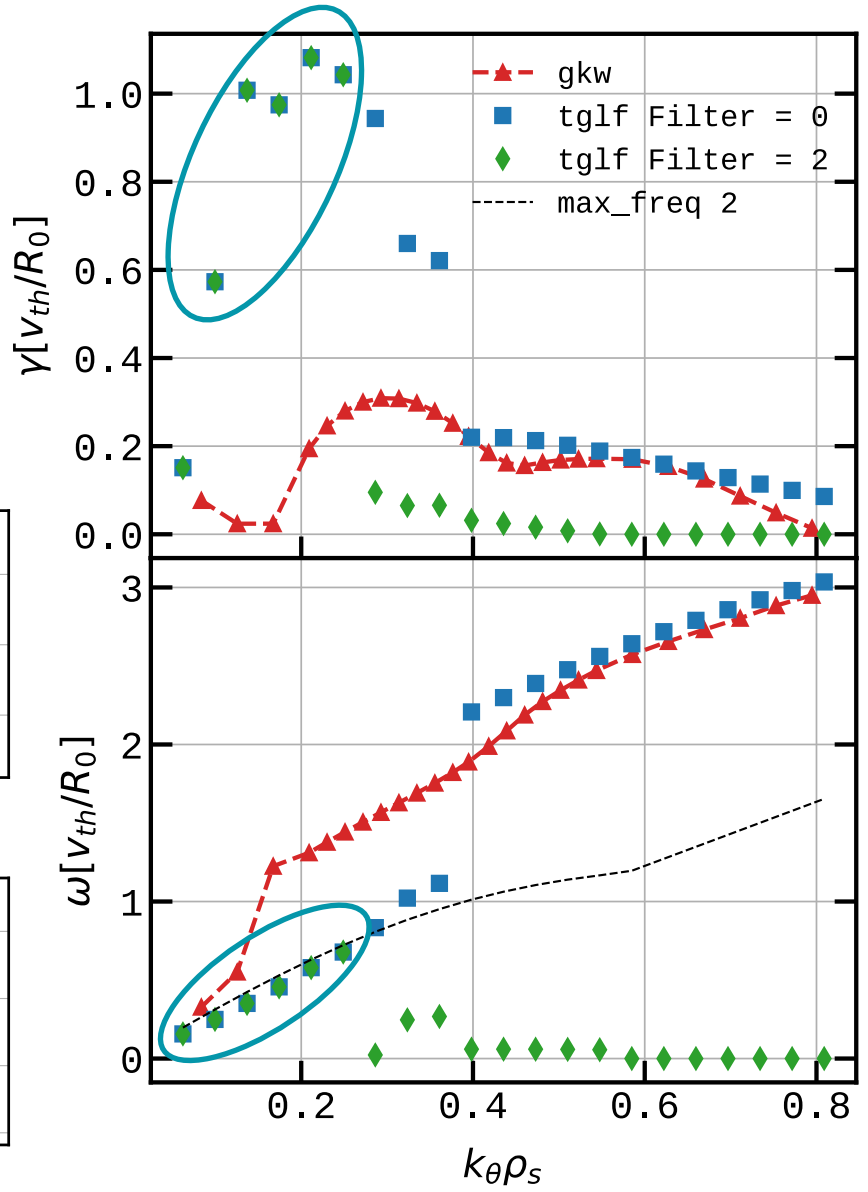
Max_freq = Filter*drift wave freq





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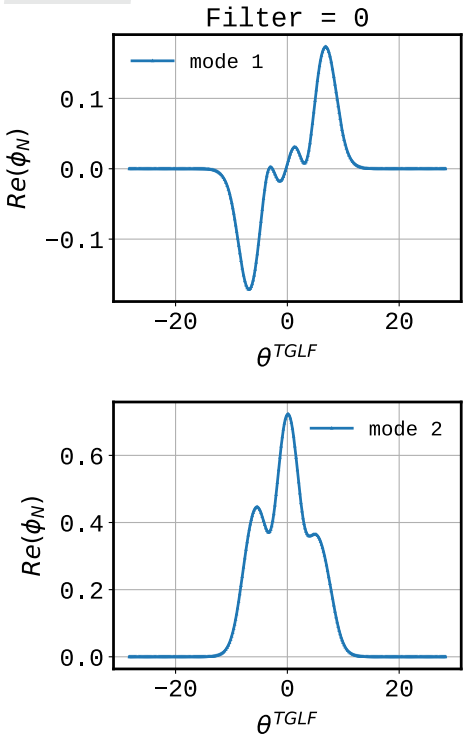

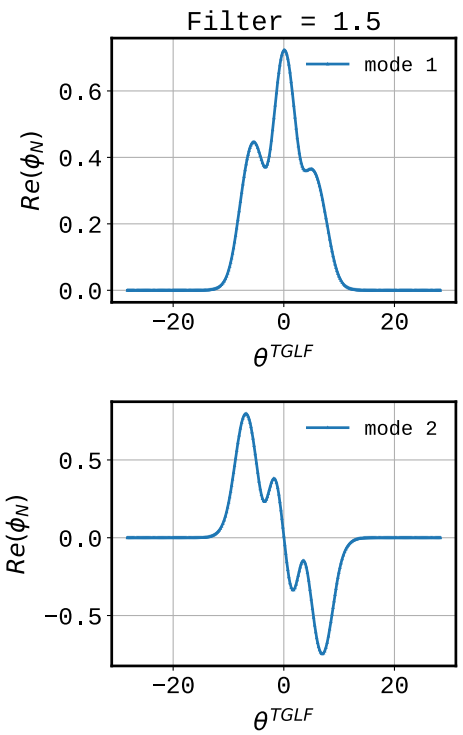

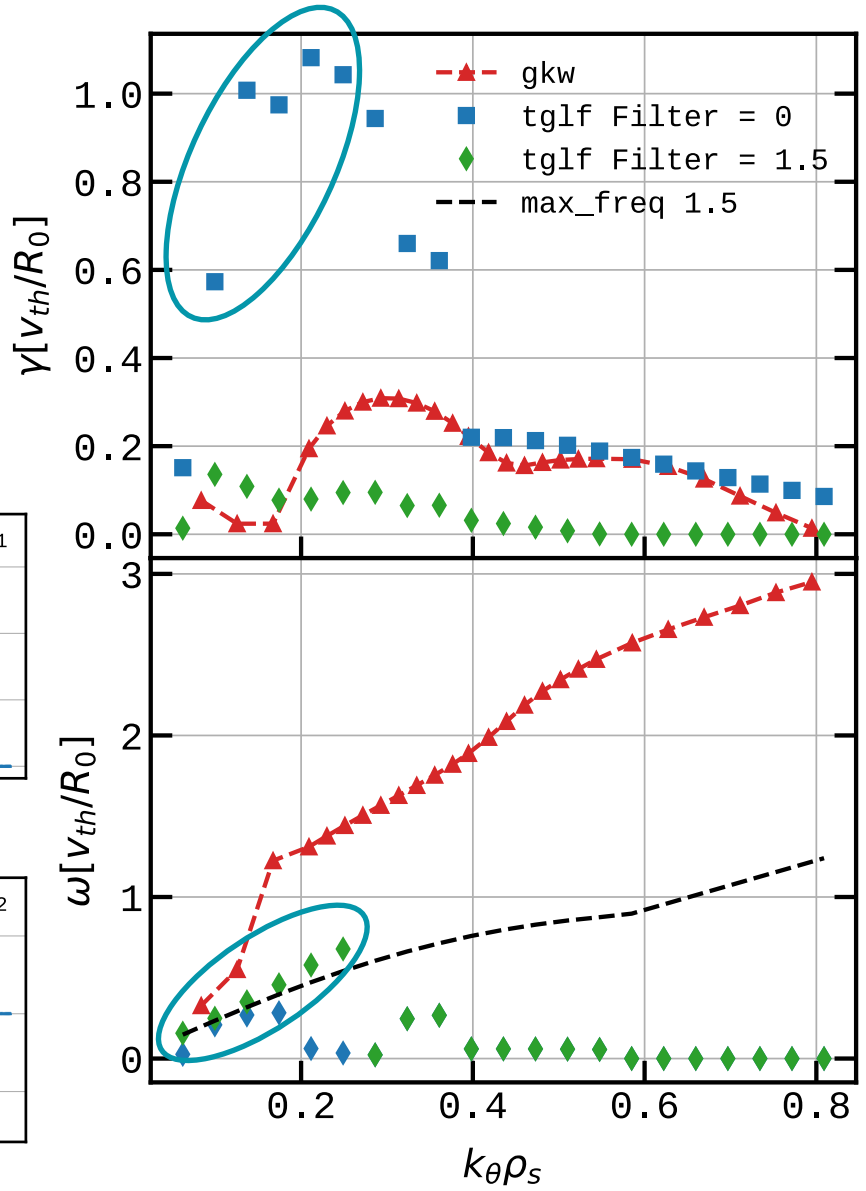

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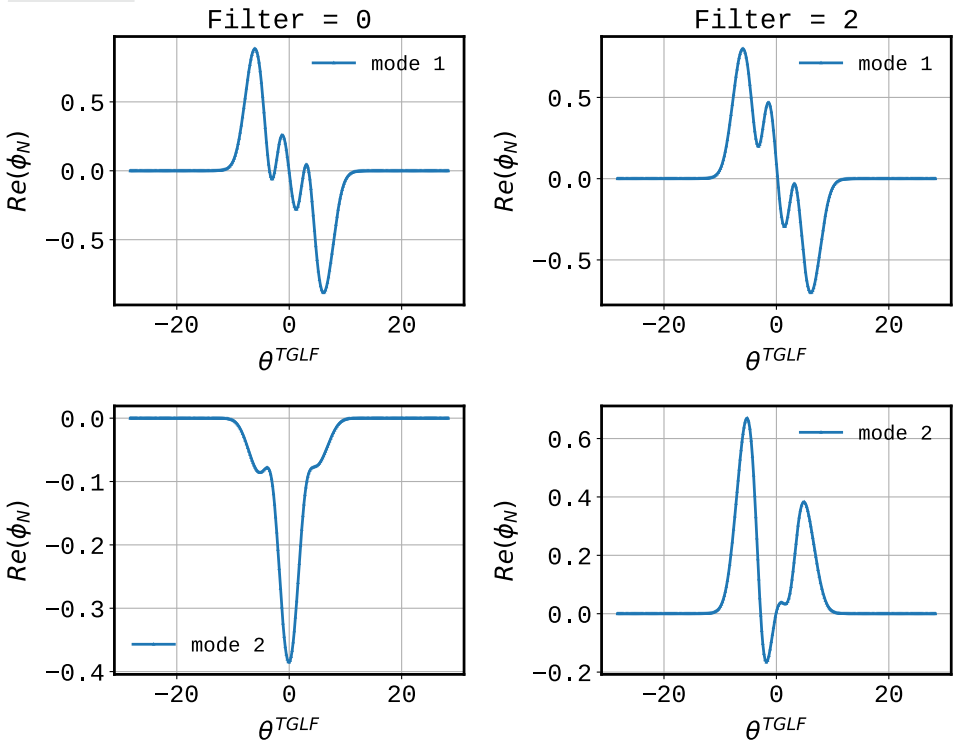

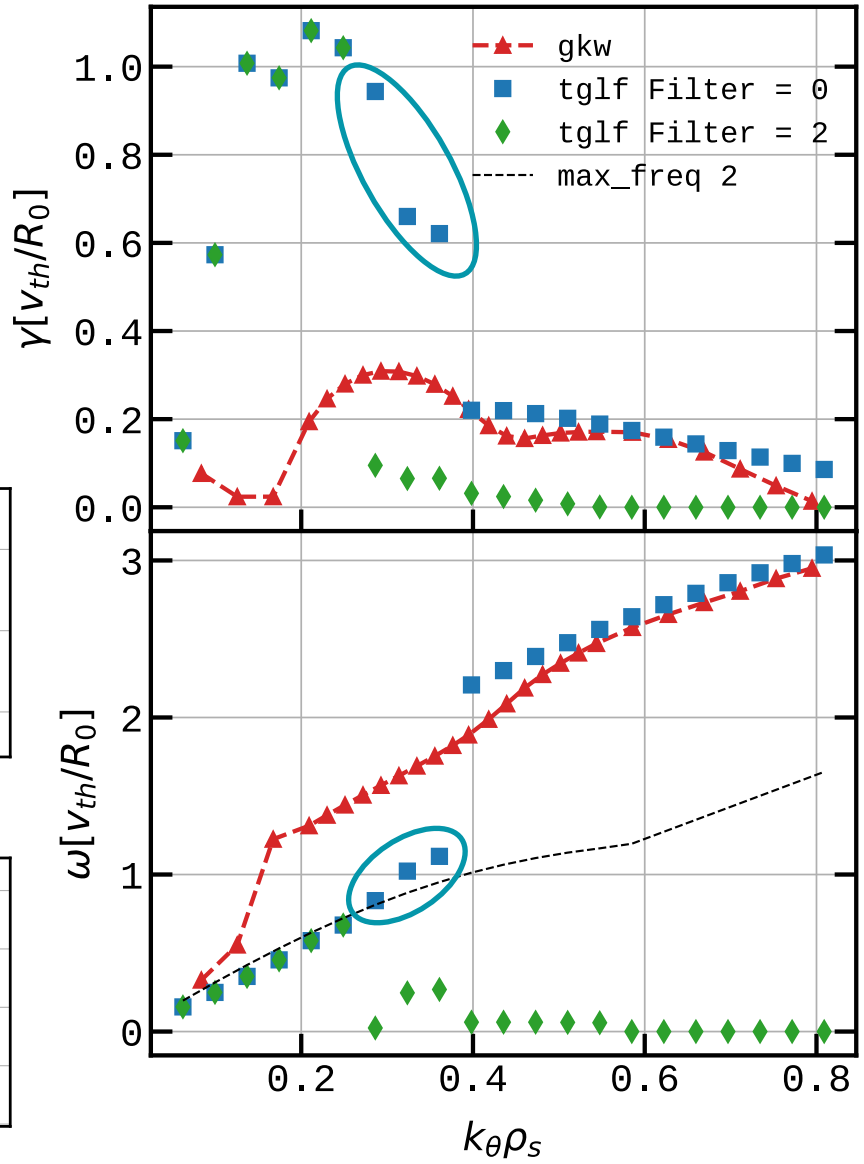

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