LULEÅ UNIVERSITY OF TECHNOLOGY

UNIVERSITÉ DE LORRAINE | EEIGM

,

Education and Culture

Erasmus Mundus

UNIVERSITÄT DES SAARLANDES

LULEÅ UNIVERSITY OF TECHNOLOGY

Linköping University

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

UNIVERSITÉ DE LORRAINE

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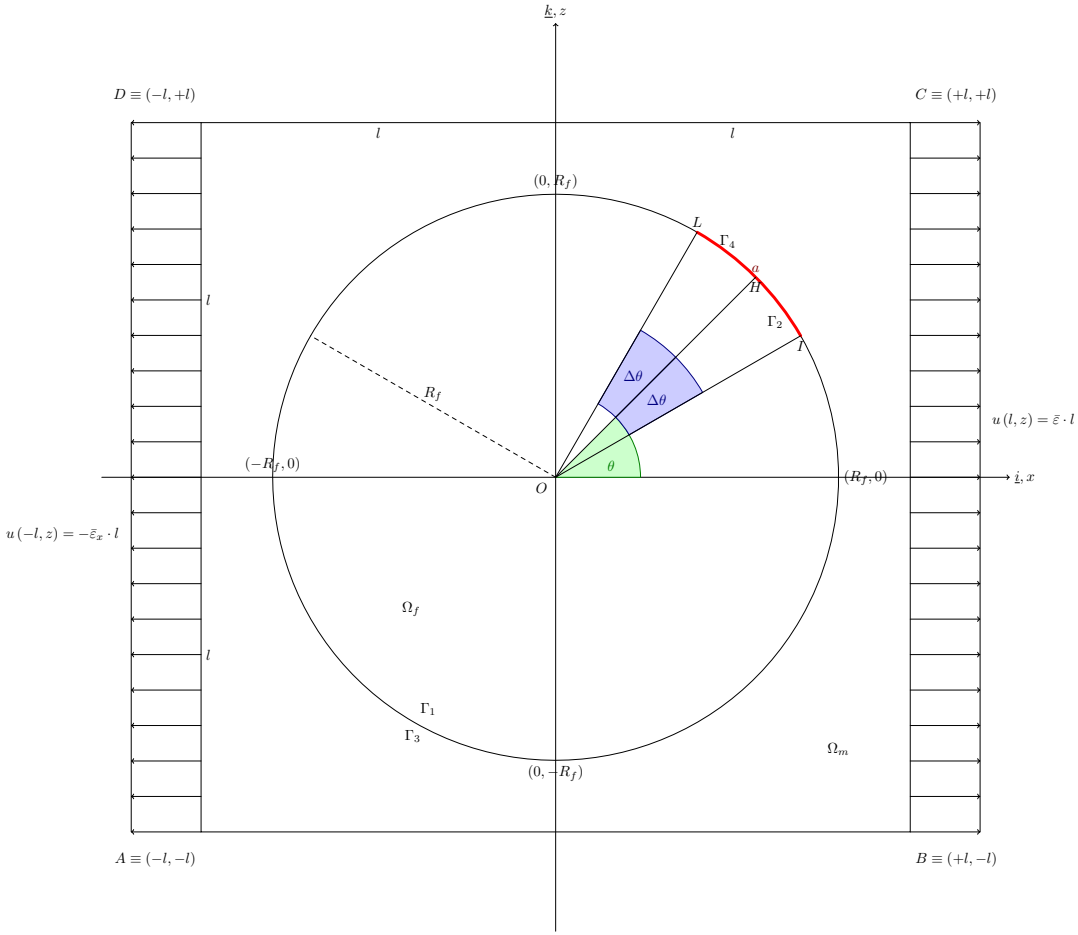
$\underline{k}, z$
$D \equiv (-l, +l)$
$C \equiv (+l, +l)$
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Γ_4
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R_f
$u(l, z) = \bar{\varepsilon} \cdot l$
$(-R_f, 0)$
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O
$(R_f, 0)$
$\underline{i}, x$
$u(-l, z) = -\bar{\varepsilon}_x \cdot l$
Ω_f
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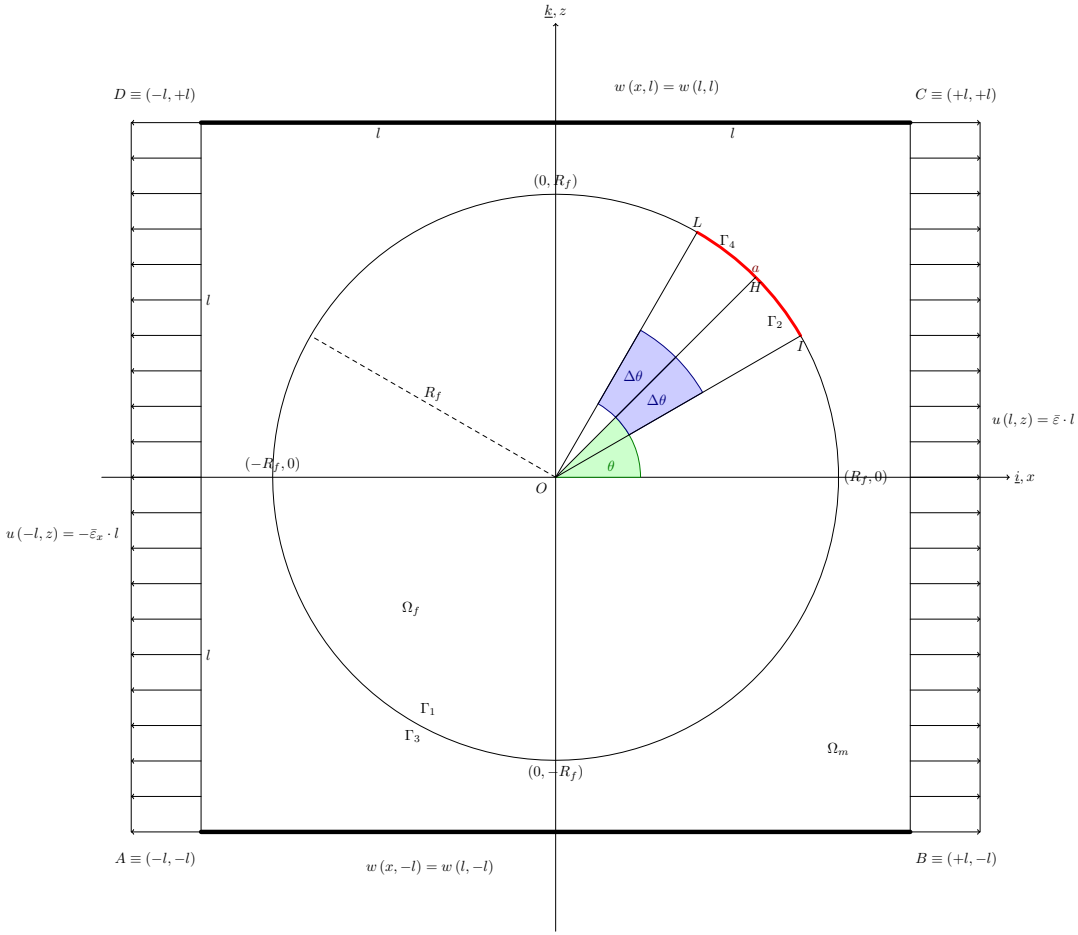
$(0, -R_f)$
$A \equiv (-l, -l)$
$B \equiv (+l, -l)$


$\underline{k}, z$
$D \equiv (-l, +l)$
$w(x, l) = w(l, l)$
$C \equiv (+l, +l)$
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$u(l, z) = \bar{\varepsilon} \cdot l$
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$\underline{i}, x$
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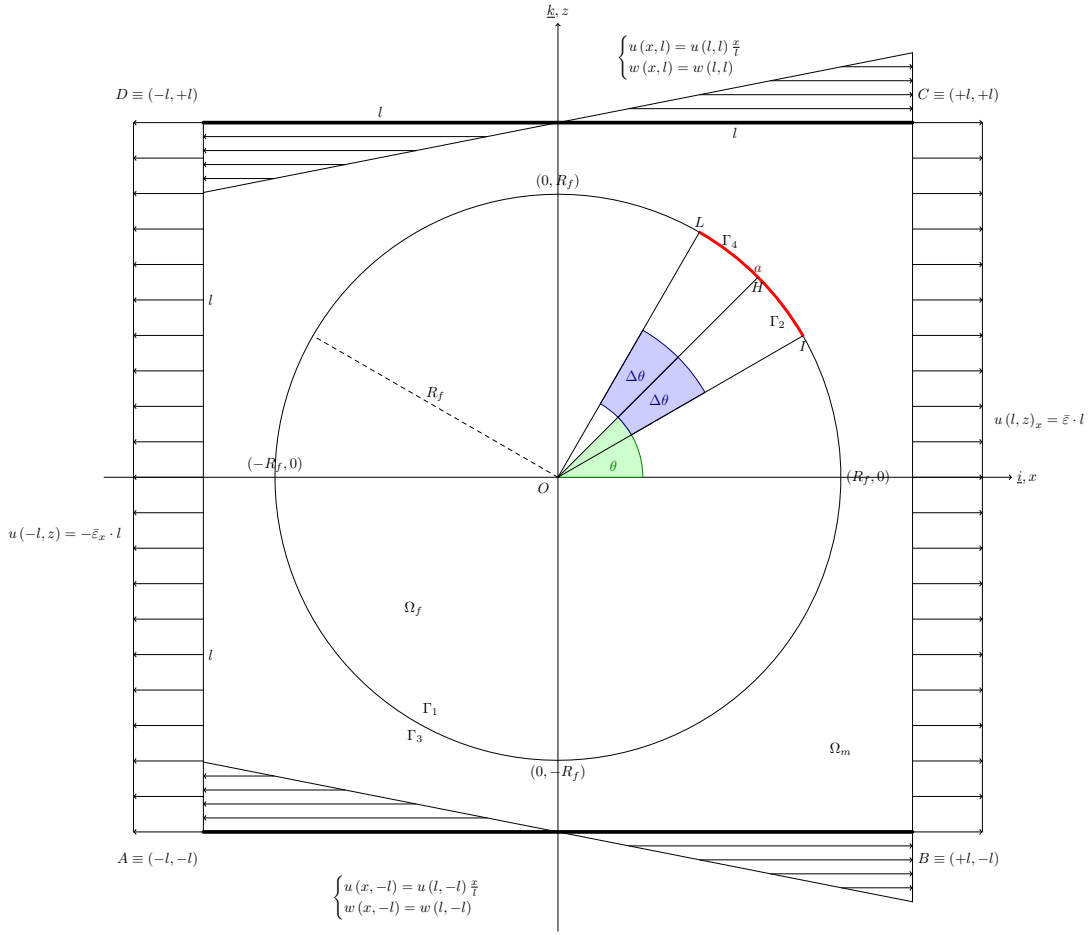
$(0, -R_f)$
$A \equiv (-l, -l)$
$w(x, -l) = w(l, -l)$
$B \equiv (+l, -l)$


$\underline{k}, z$
$\begin{cases} u(x,l) = u(l,l)\frac{x}{l} \\ w(x,l) = w(l,l) \end{cases}$
$D \equiv (-l, +l)$
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R_f
$u(l,z)_x = \bar{\varepsilon} \cdot l$
$(-R_f, 0)$
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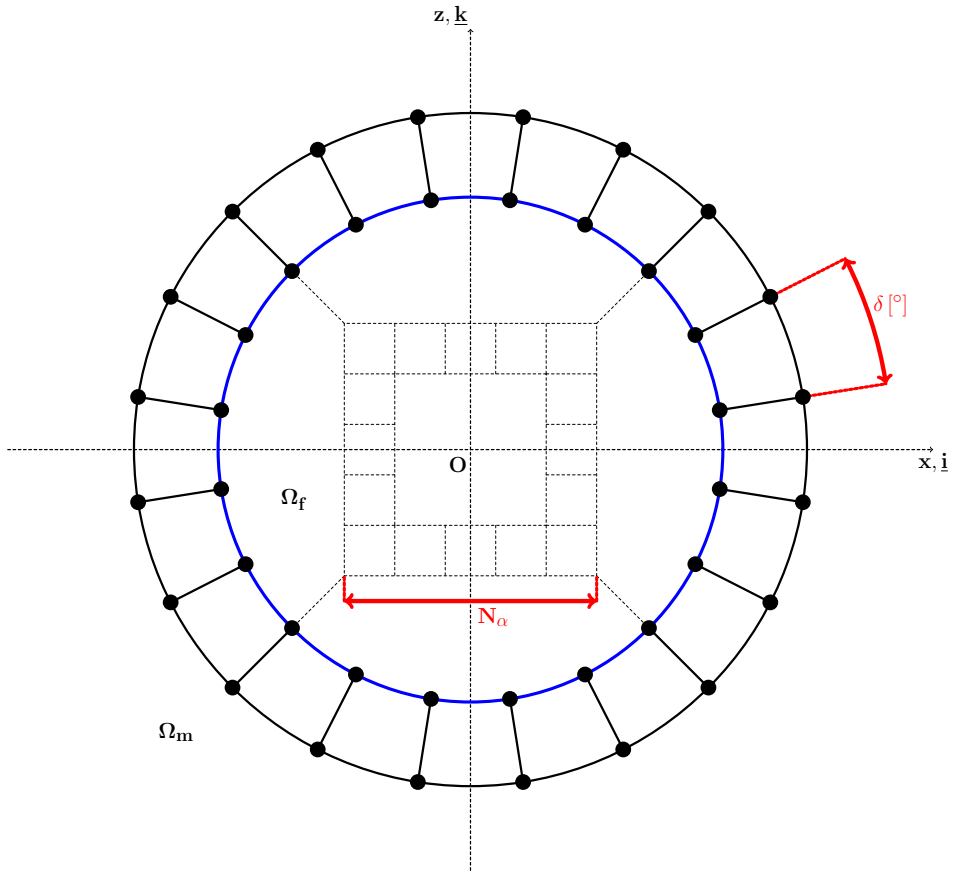
$(R_f, 0)$
$\underline{i}, x$
$u(-l,z) = -\bar{\varepsilon}_x \cdot l$
Ω_f
l
Γ_1
Γ_3
Ω_m
$(0, -R_f)$
$A \equiv (-l, -l)$
$B \equiv (+l, -l)$
$\begin{cases} u(x,-l) = u(l,-l)\frac{x}{l} \\ w(x,-l) = w(l,-l) \end{cases}$



$$\delta = \frac{\circ}{\alpha}$$

[] [] ν [–]

$$= \pi\sigma \frac{+}{\quad}$$

$$= \; -\nu$$

$$\sigma = \frac{\quad}{-\nu}\varepsilon$$

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$$\Delta = \left|\Delta - \Delta\right|$$

$$\beta = \begin{pmatrix} , \\ - \\ , \end{pmatrix}$$

$$\Delta = (\beta)\Delta + (\beta)\Delta\Delta_\theta = -(\beta)\Delta + (\beta)\Delta$$

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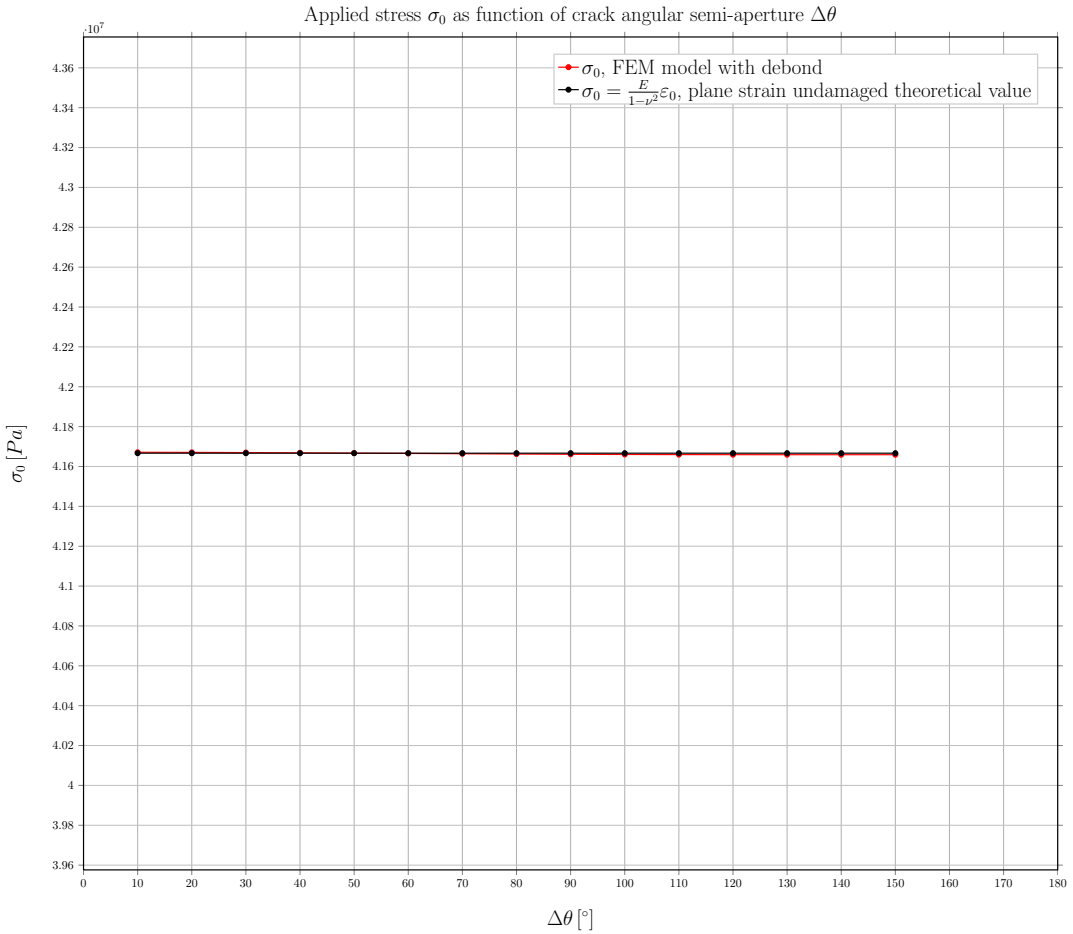
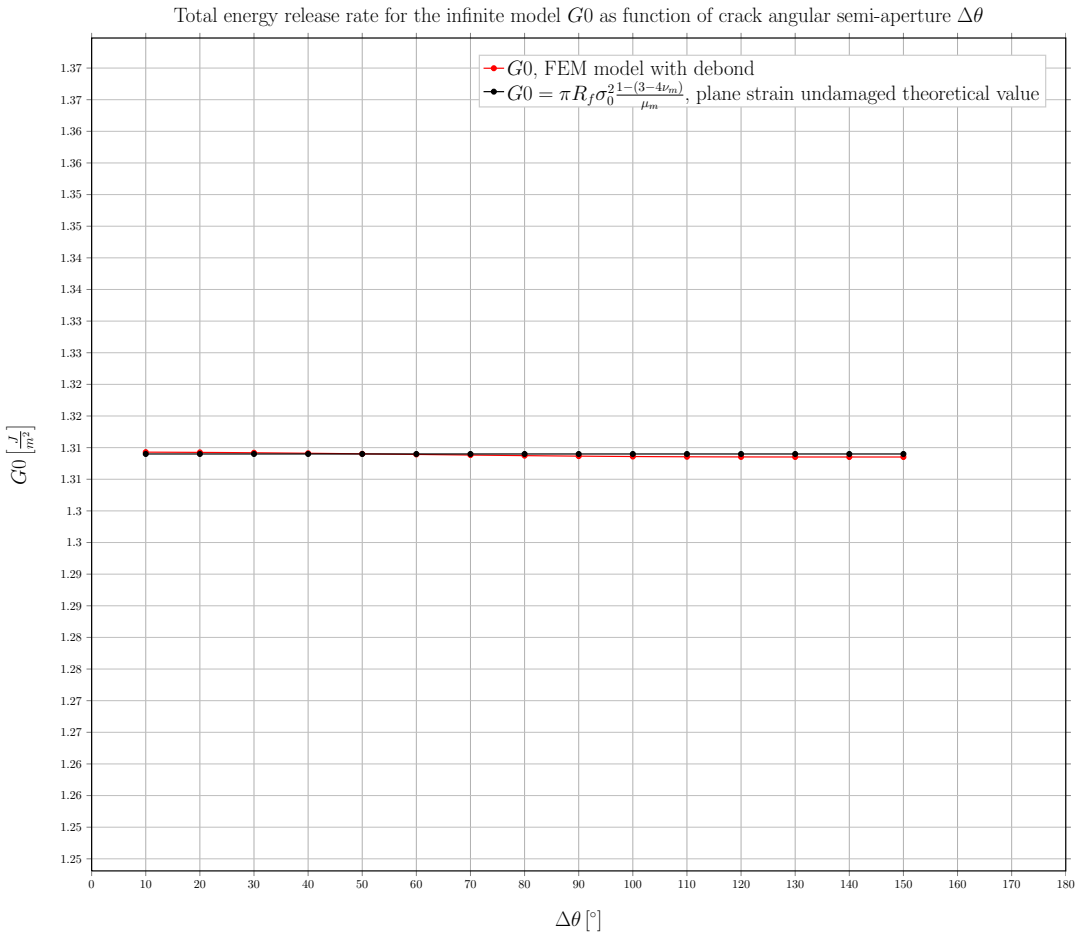
$\sigma\delta = .^\circ$

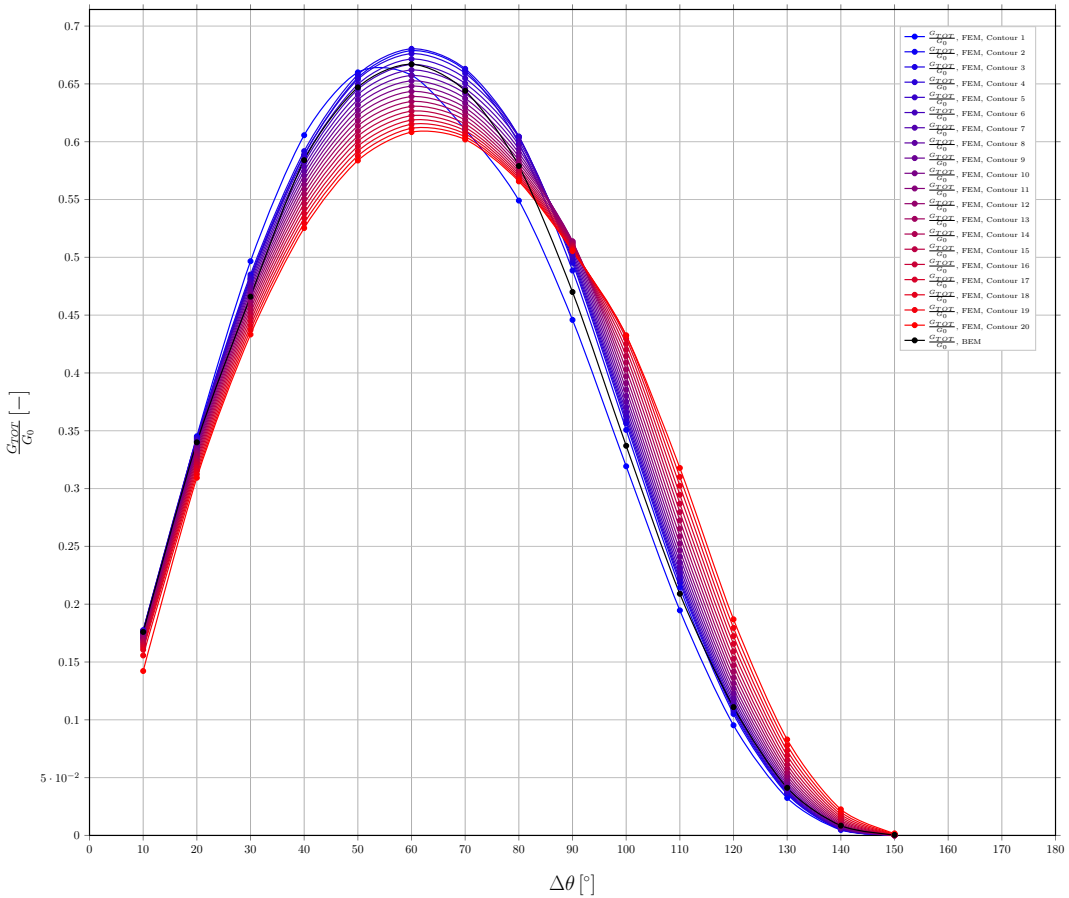


$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

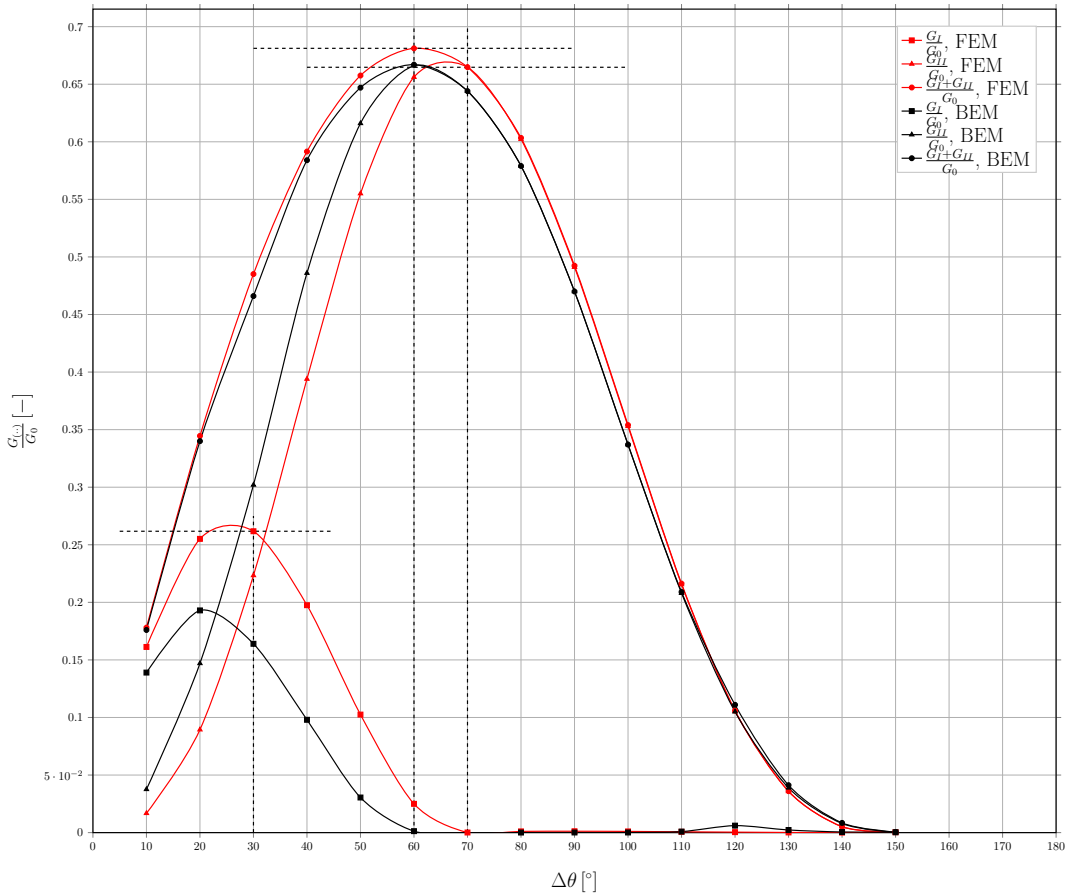
$\delta = .^\circ$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



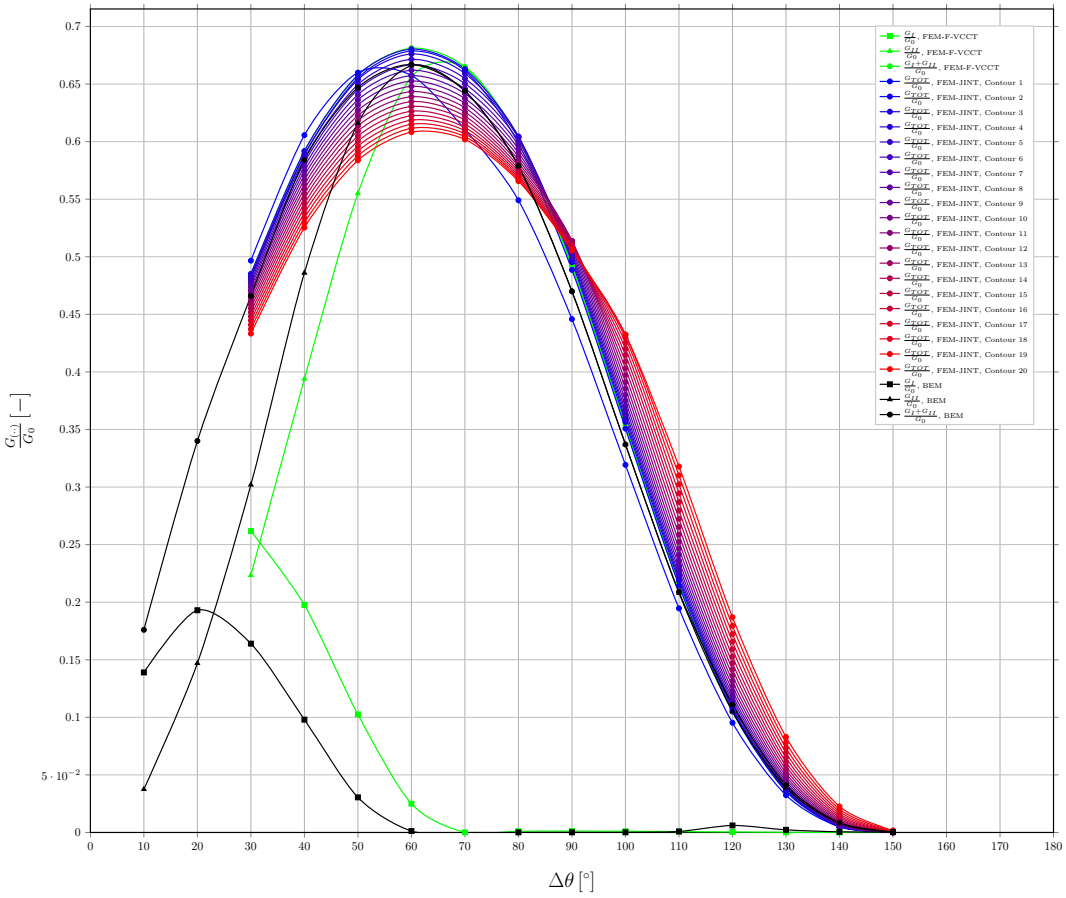
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

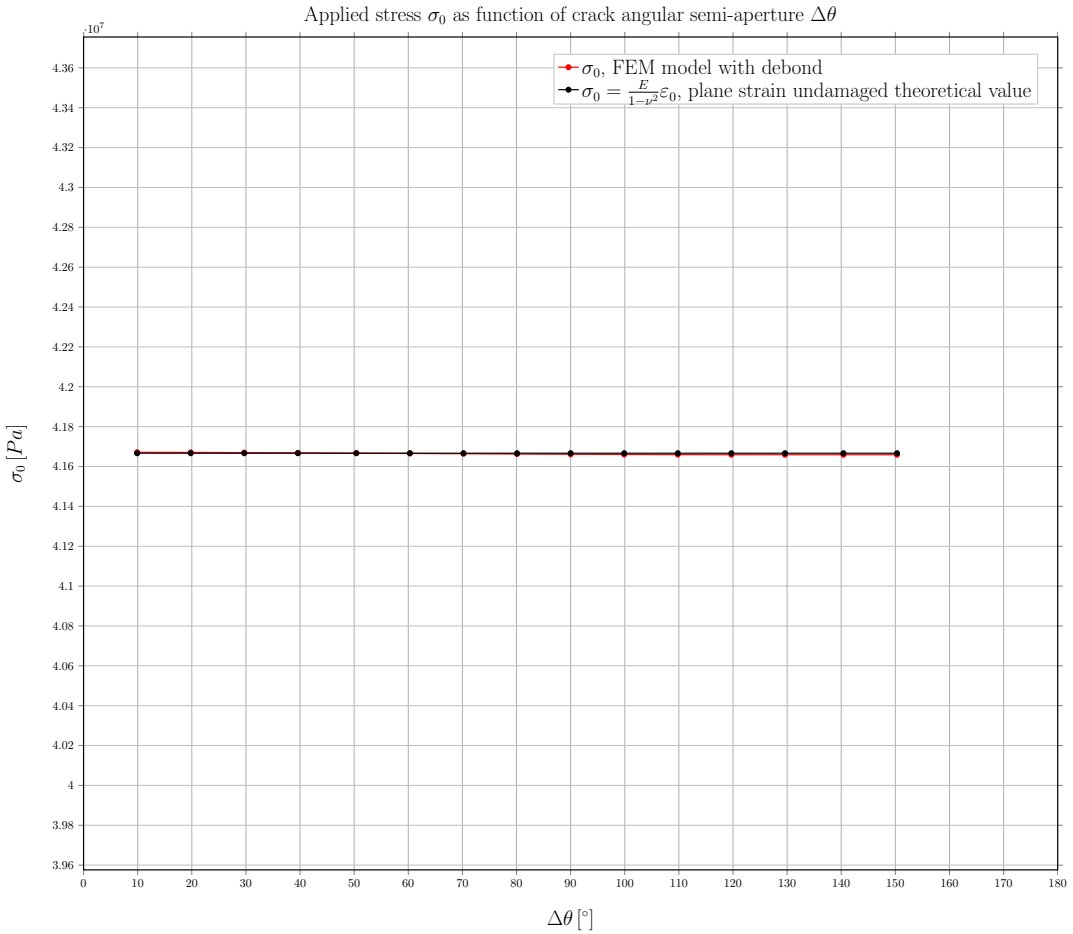


$\delta = .^{\circ}$

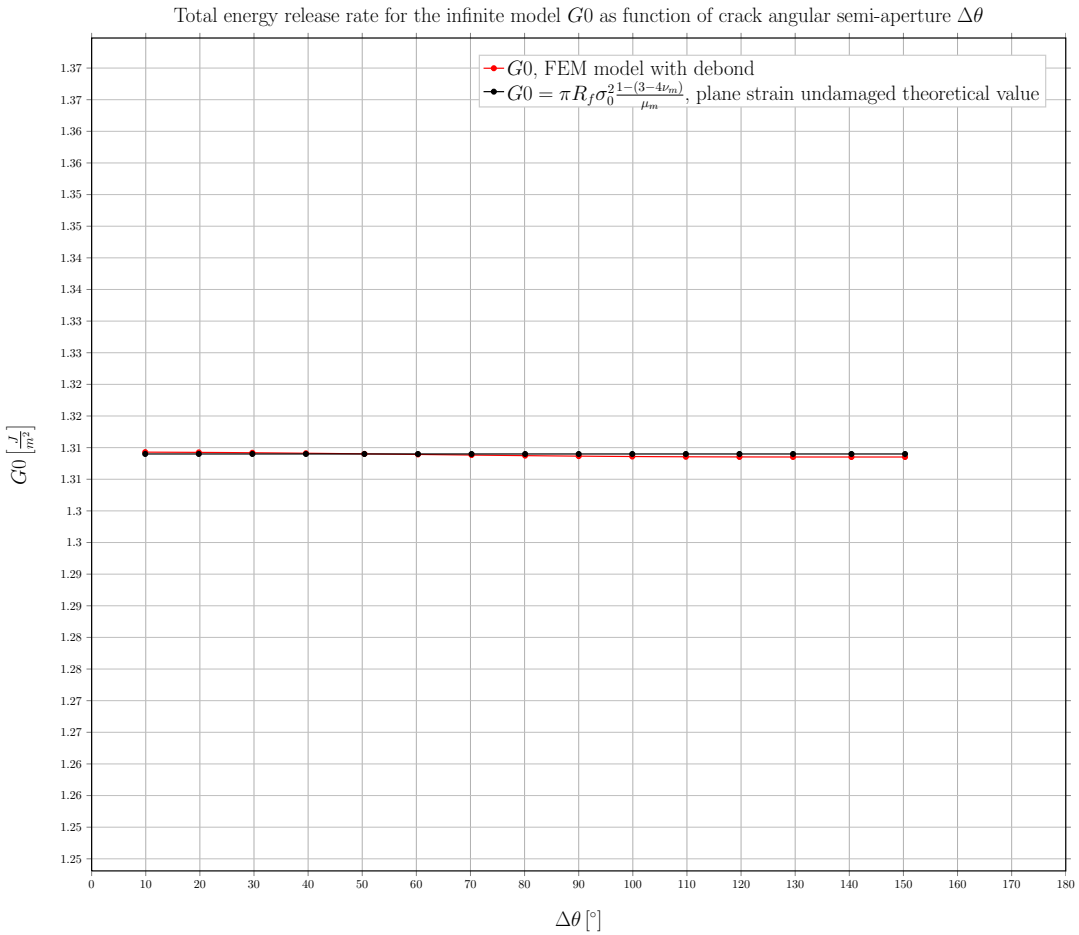
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^{\circ}$

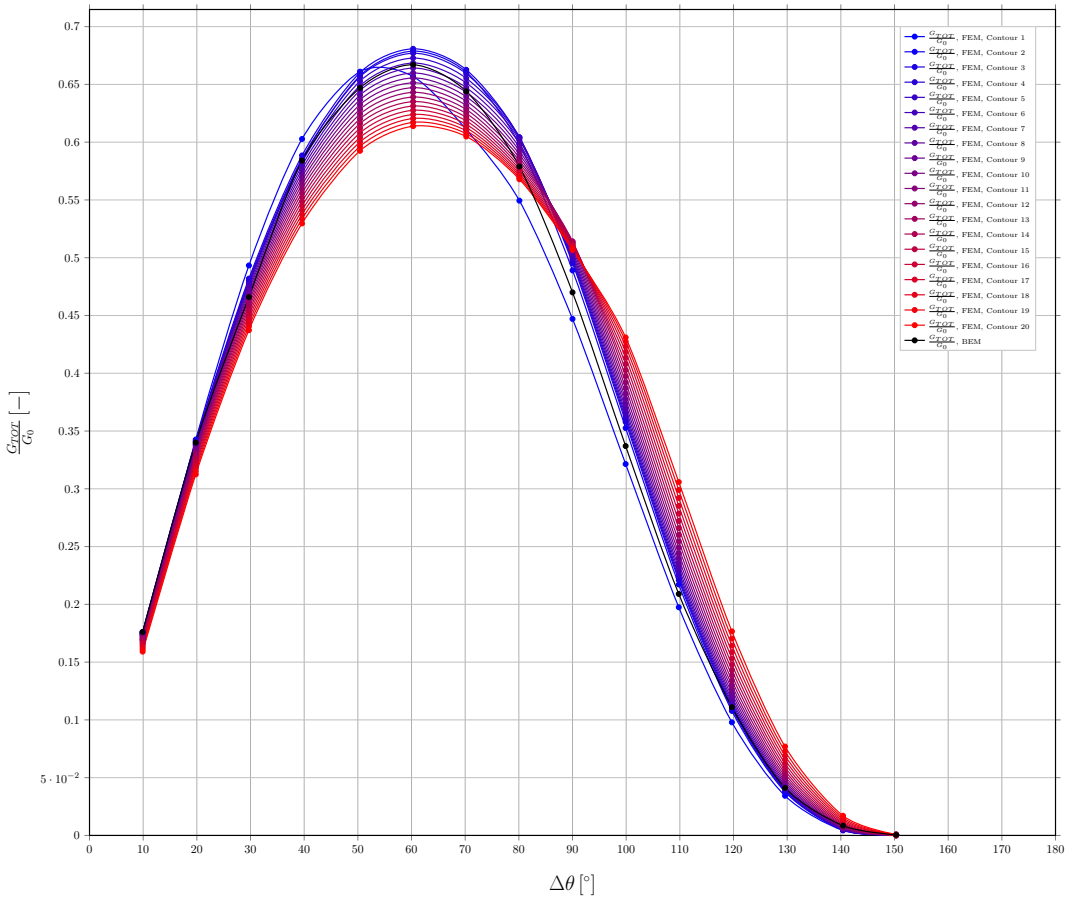


$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

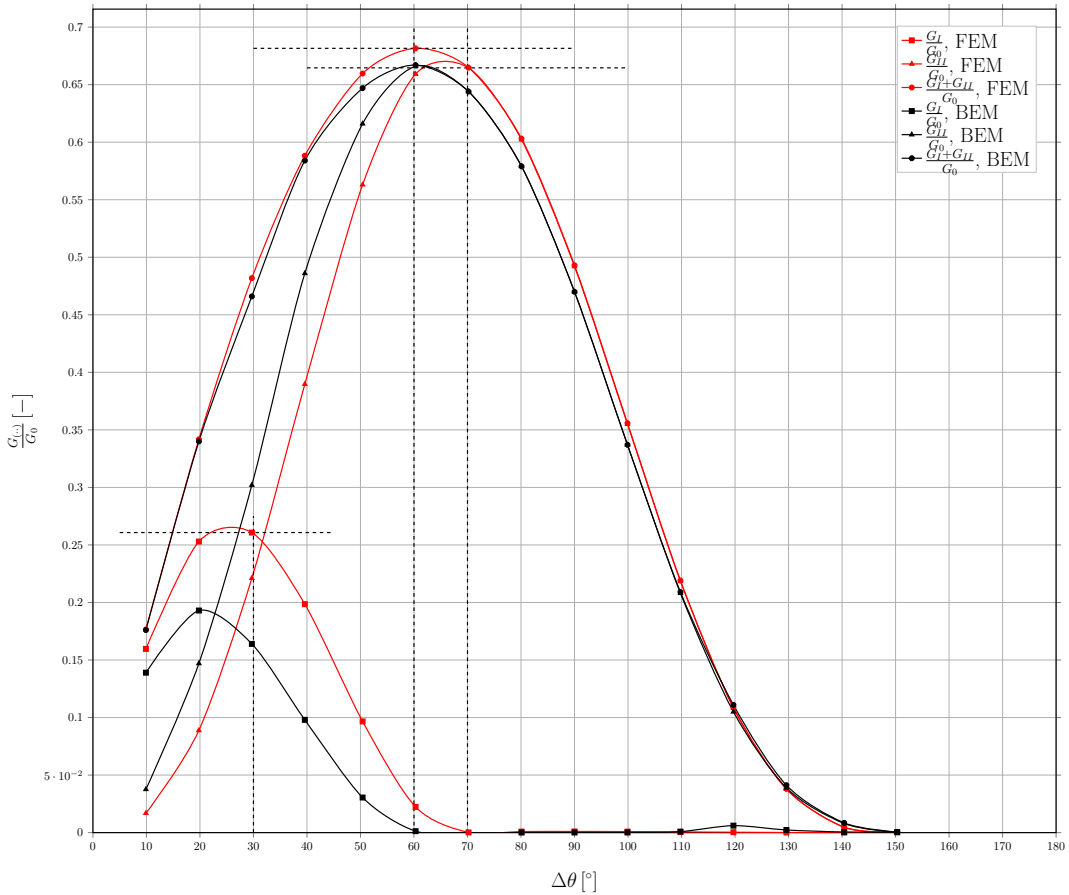
$\delta = .^{\circ}$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



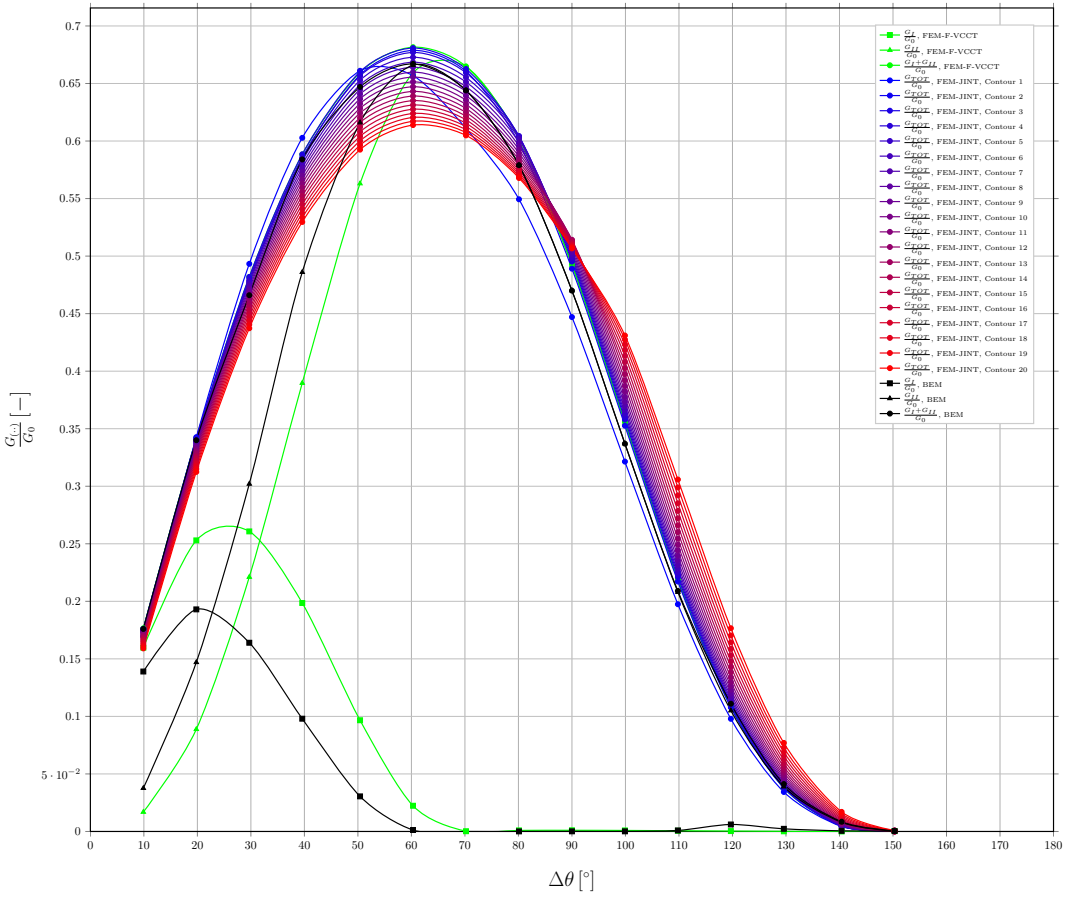
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

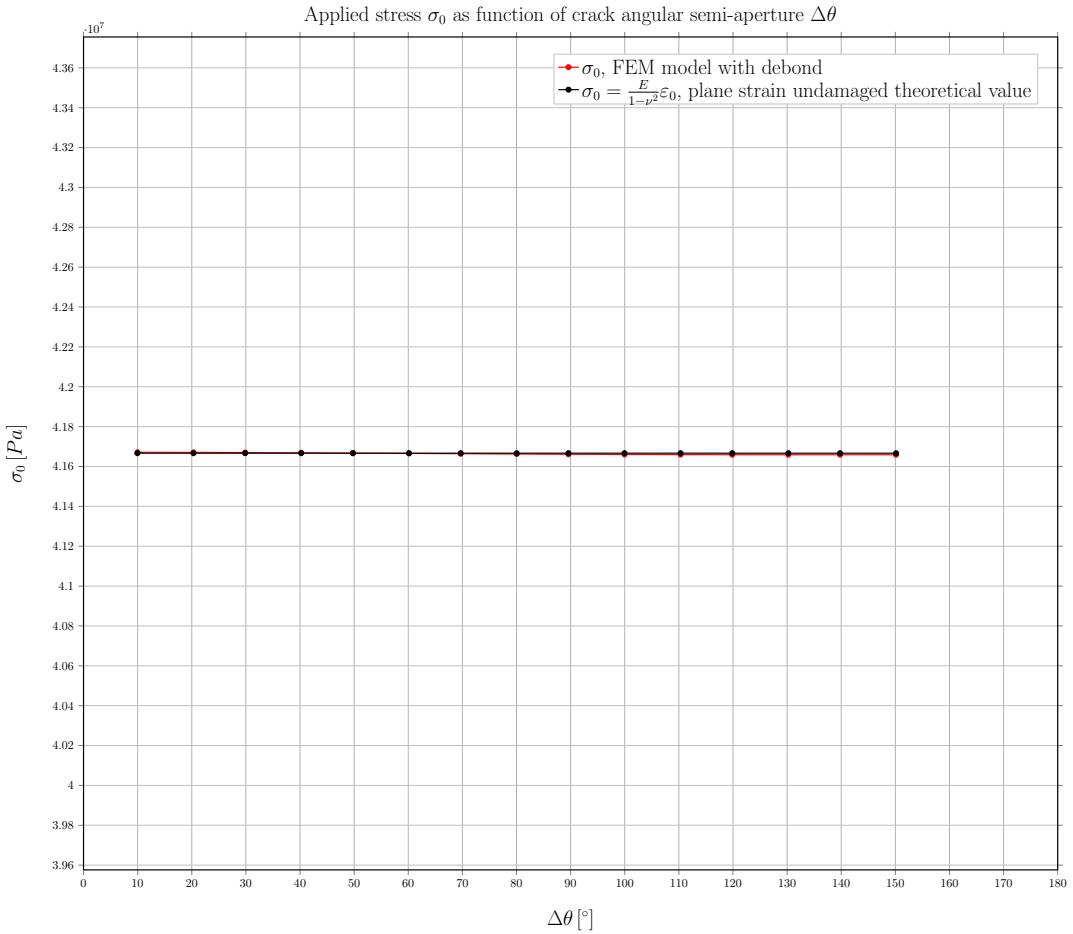


$\delta = .^{\circ}$

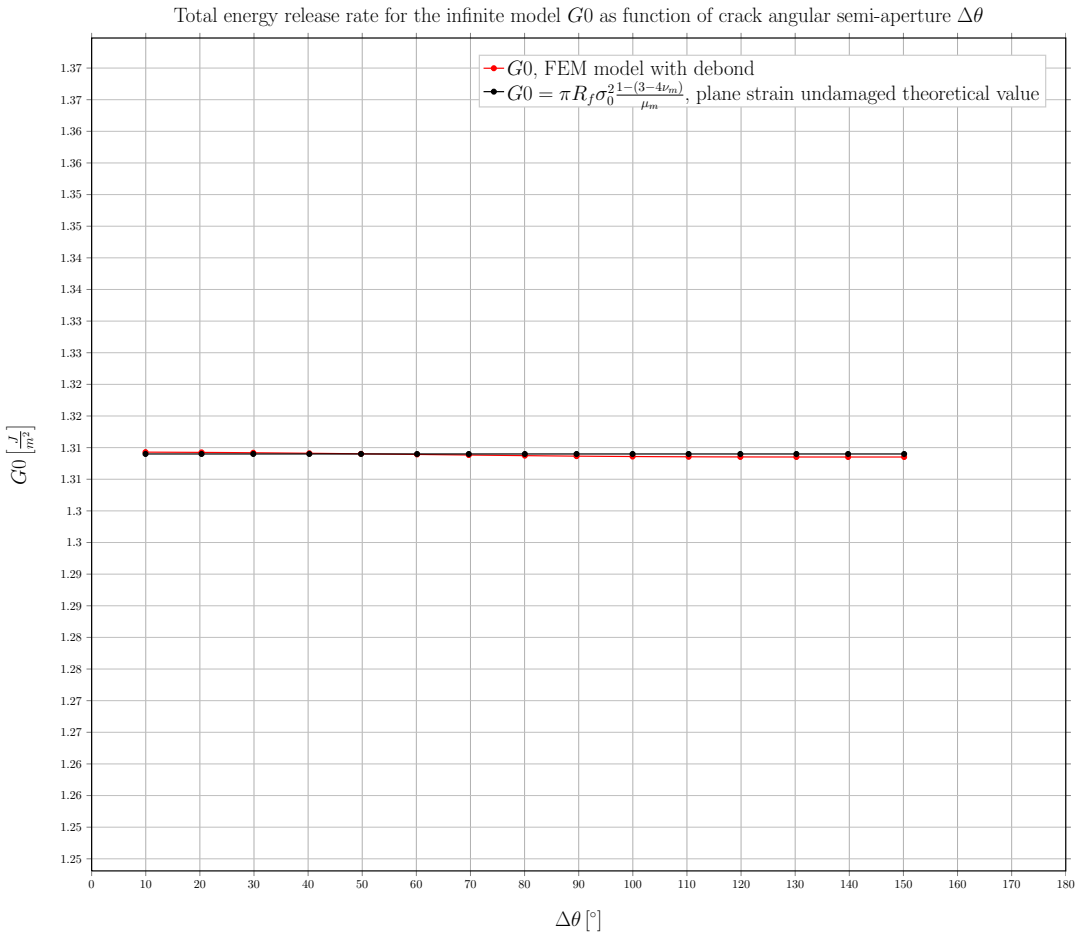
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^{\circ}$

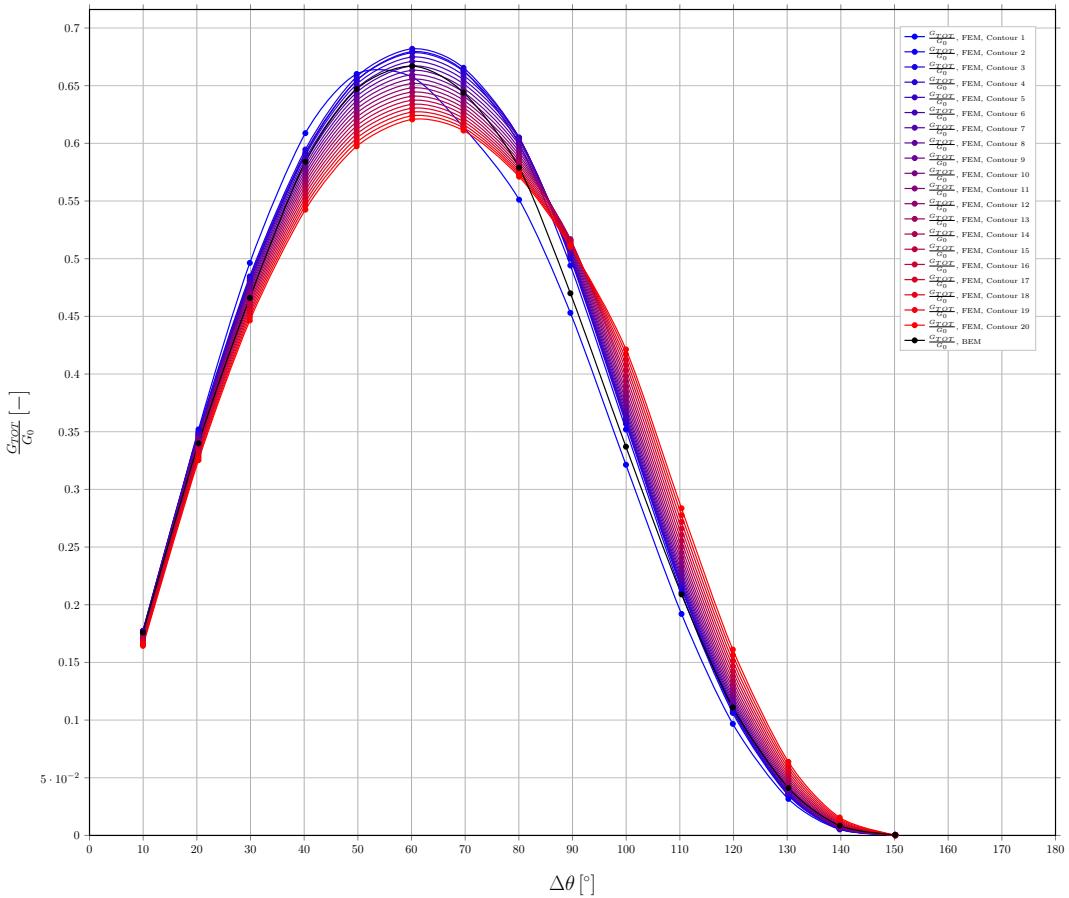


$\delta = .^\circ$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^\circ]$

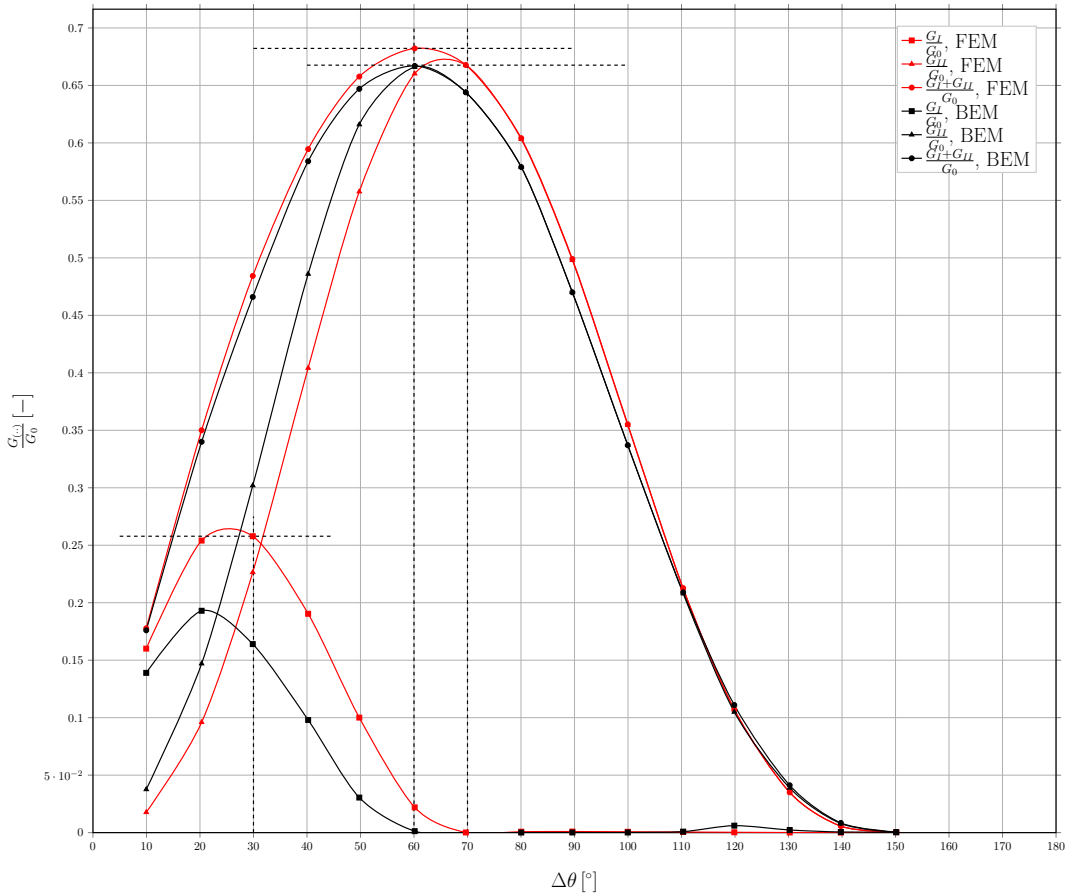
$\delta = .^\circ$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



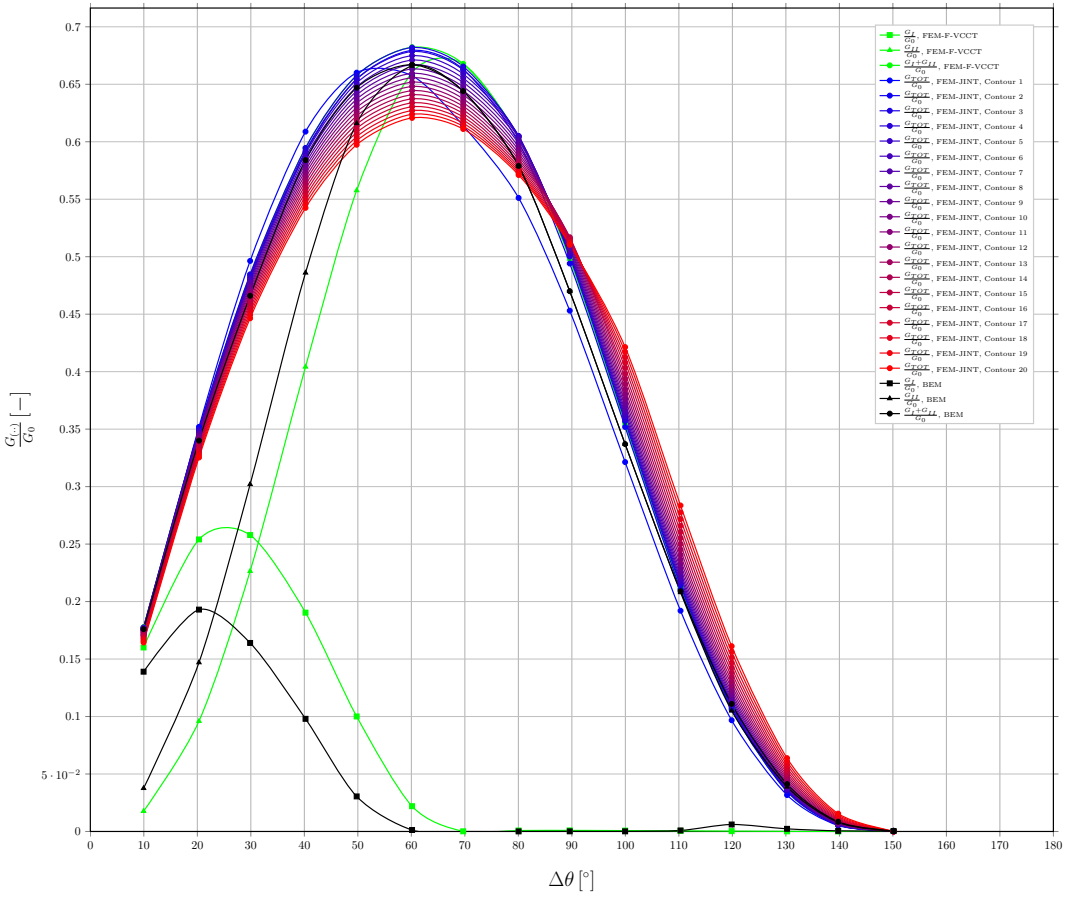
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

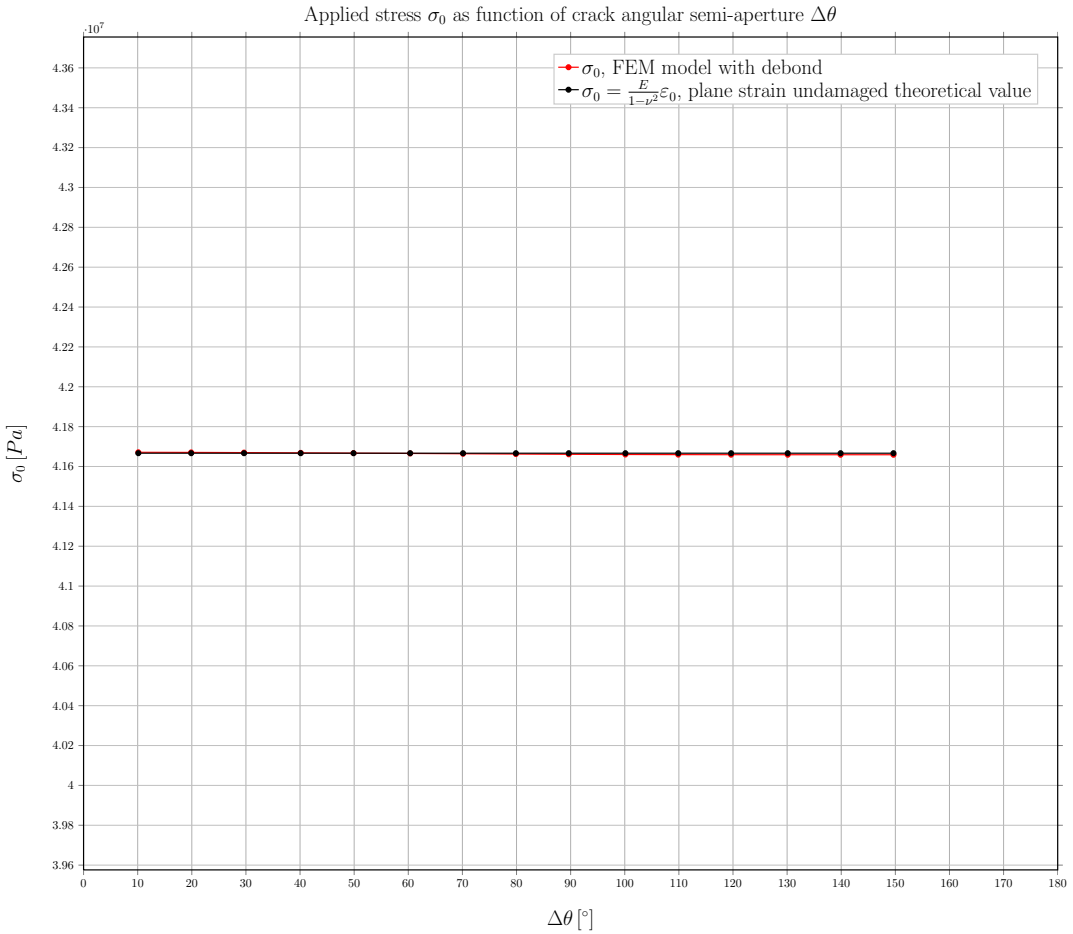


$\delta = .^{\circ}$

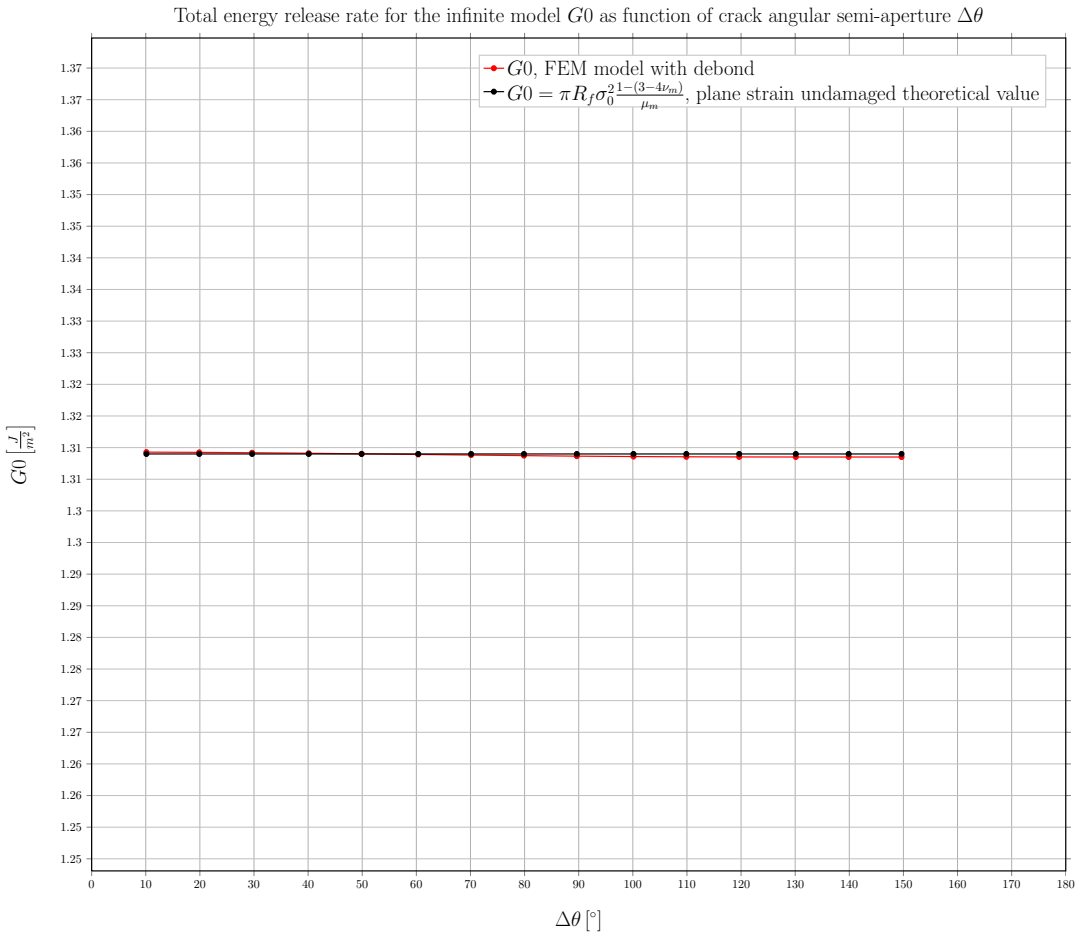
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^{\circ}$

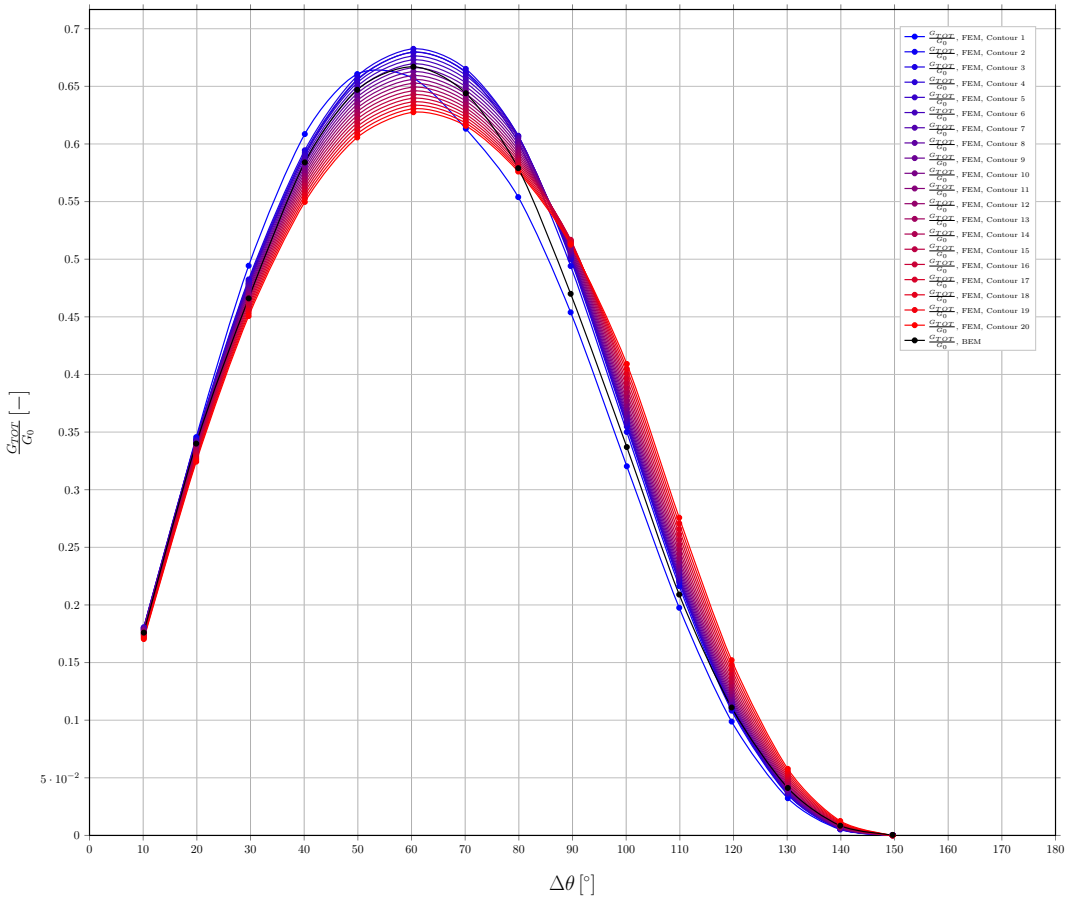


$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

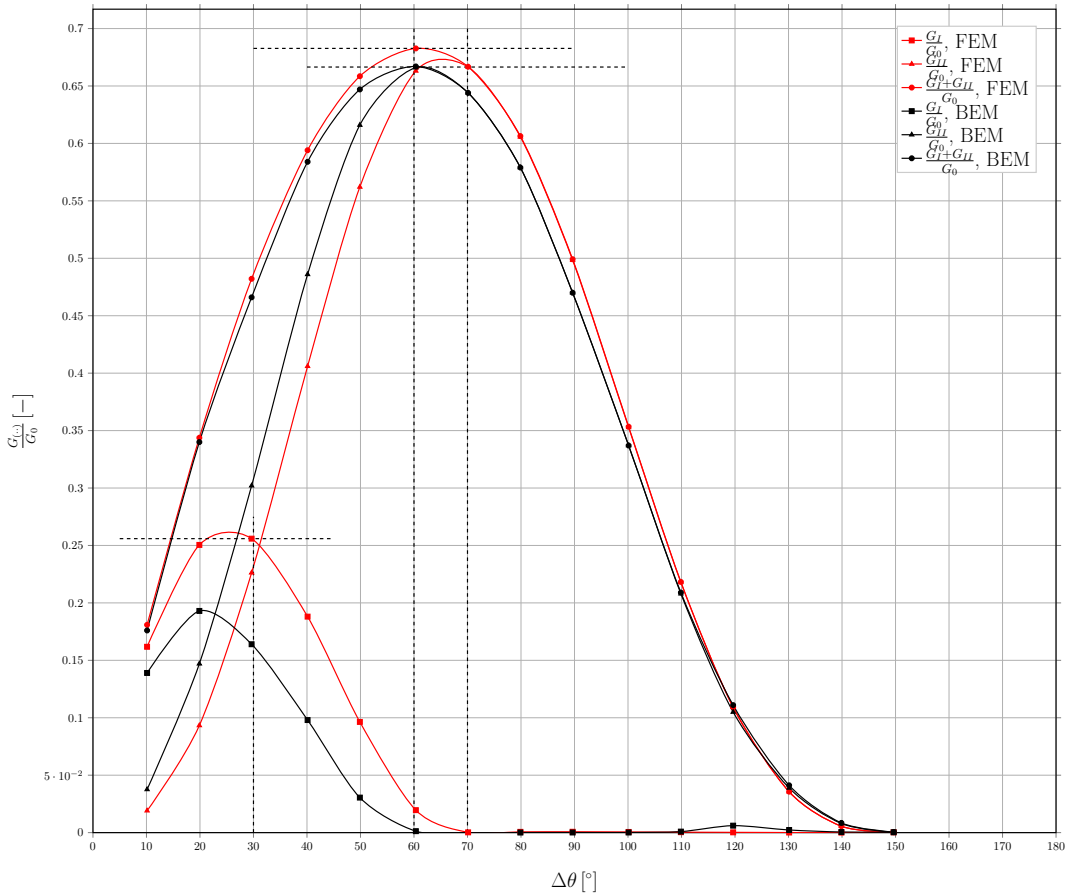
$\delta = .^{\circ}$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



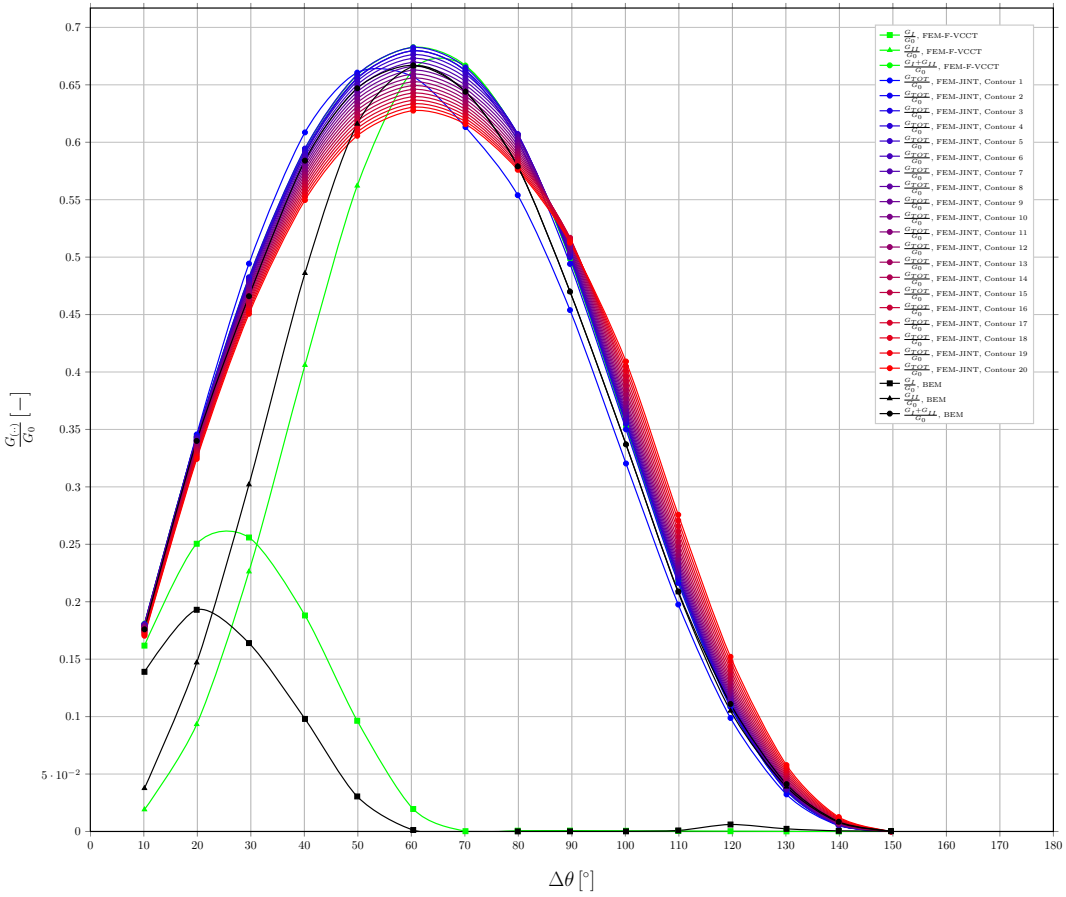
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(-)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

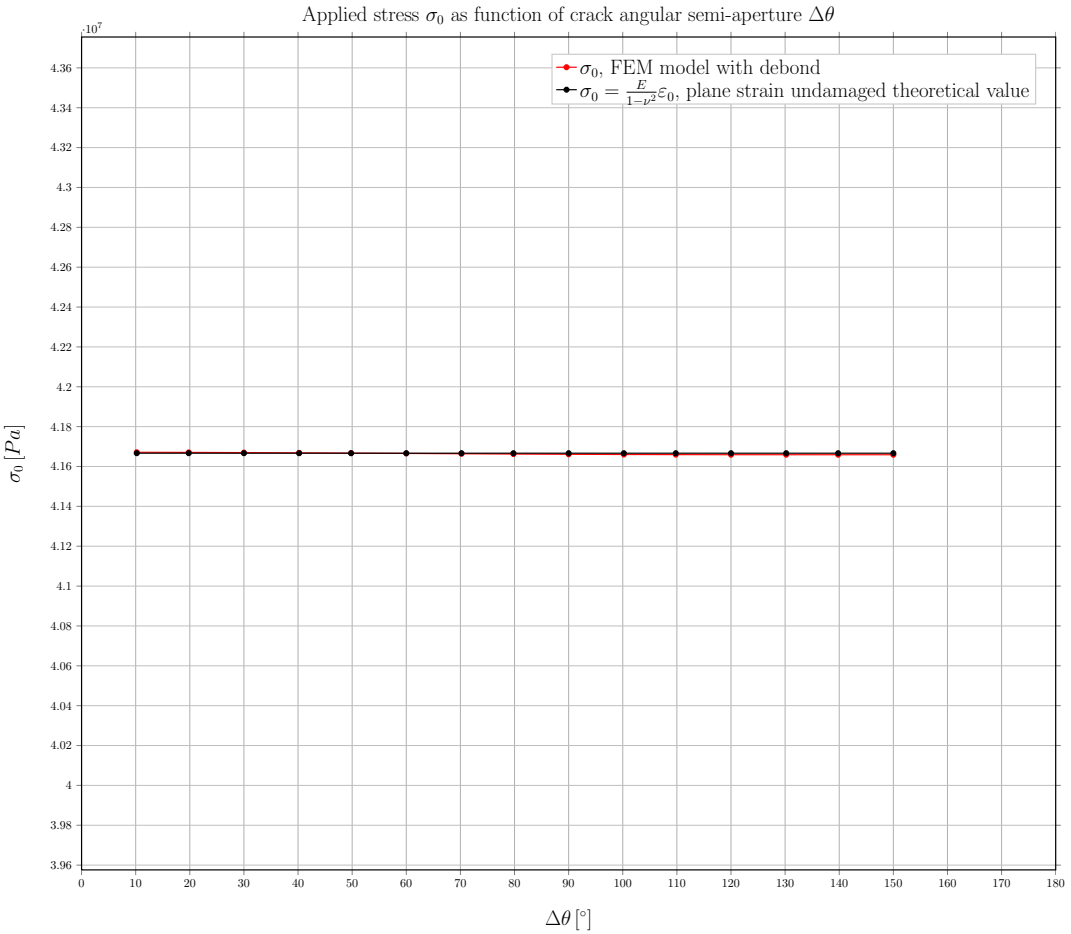


$\delta = .^\circ$

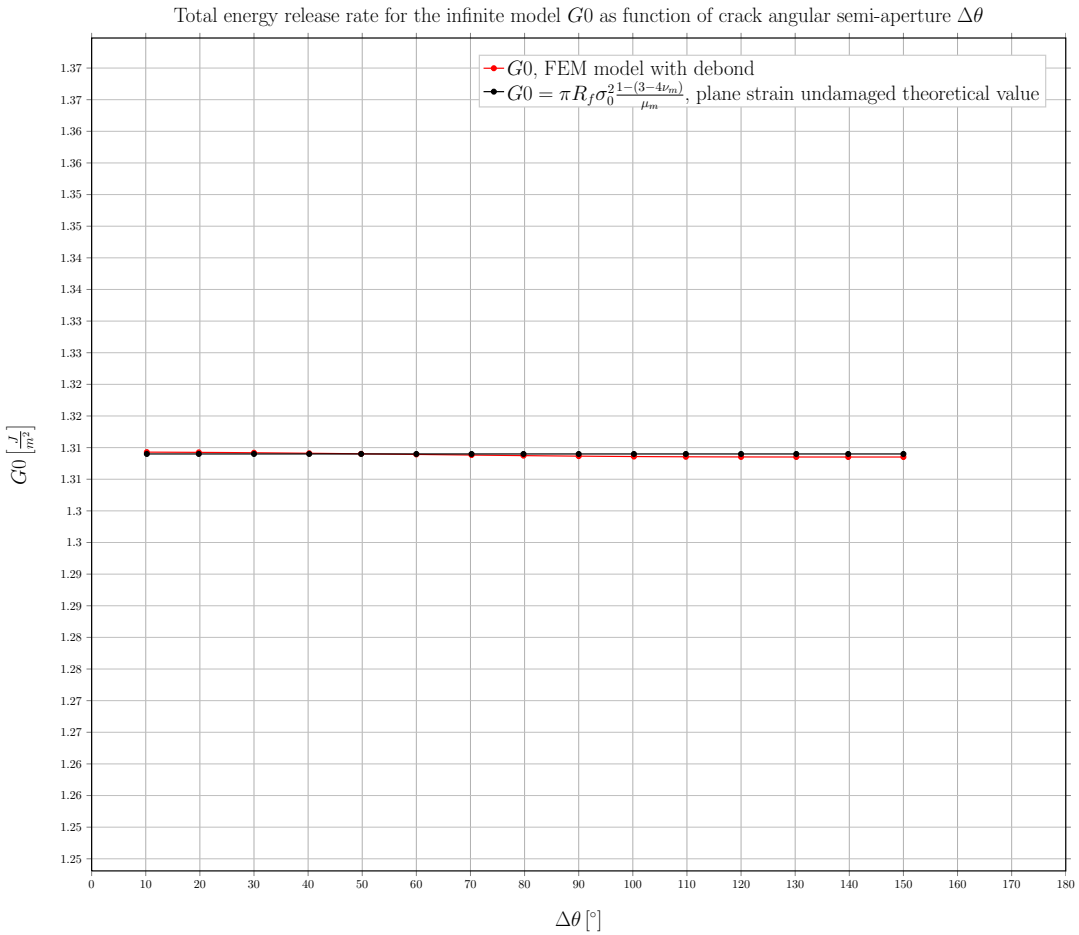
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^\circ$

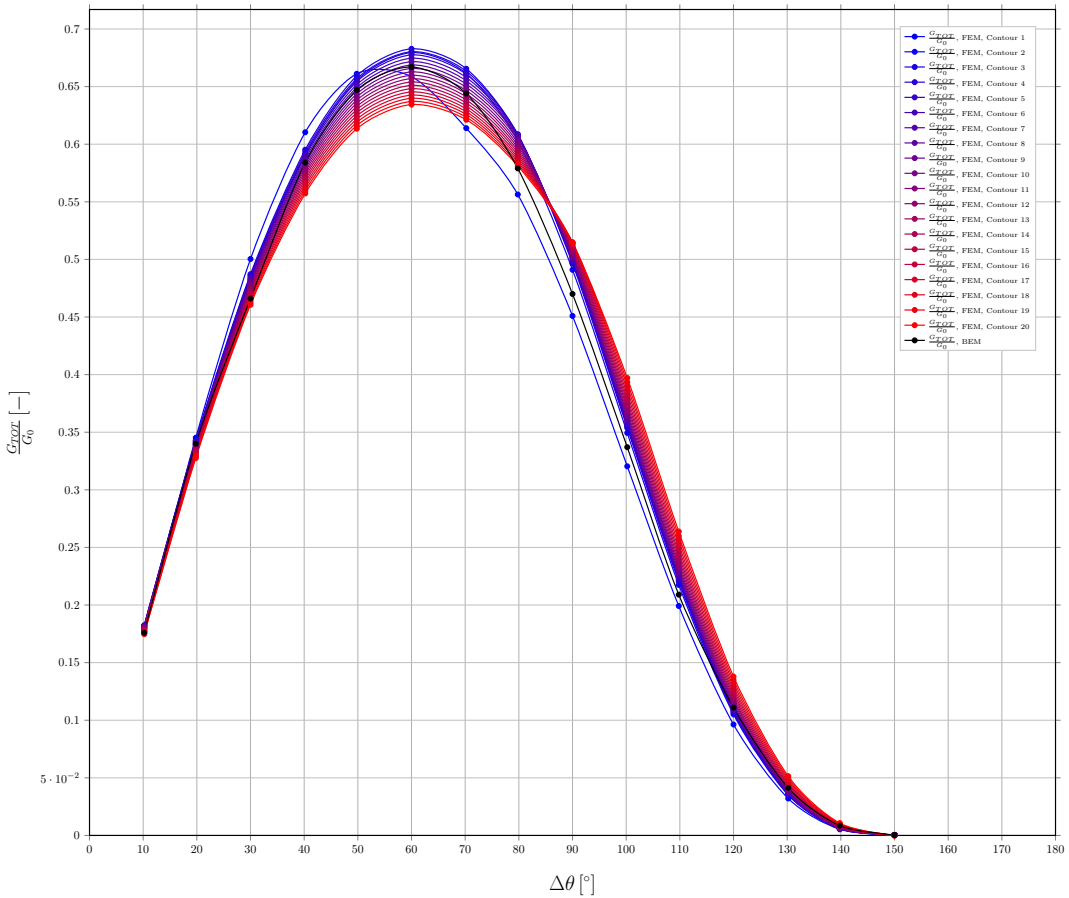


$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

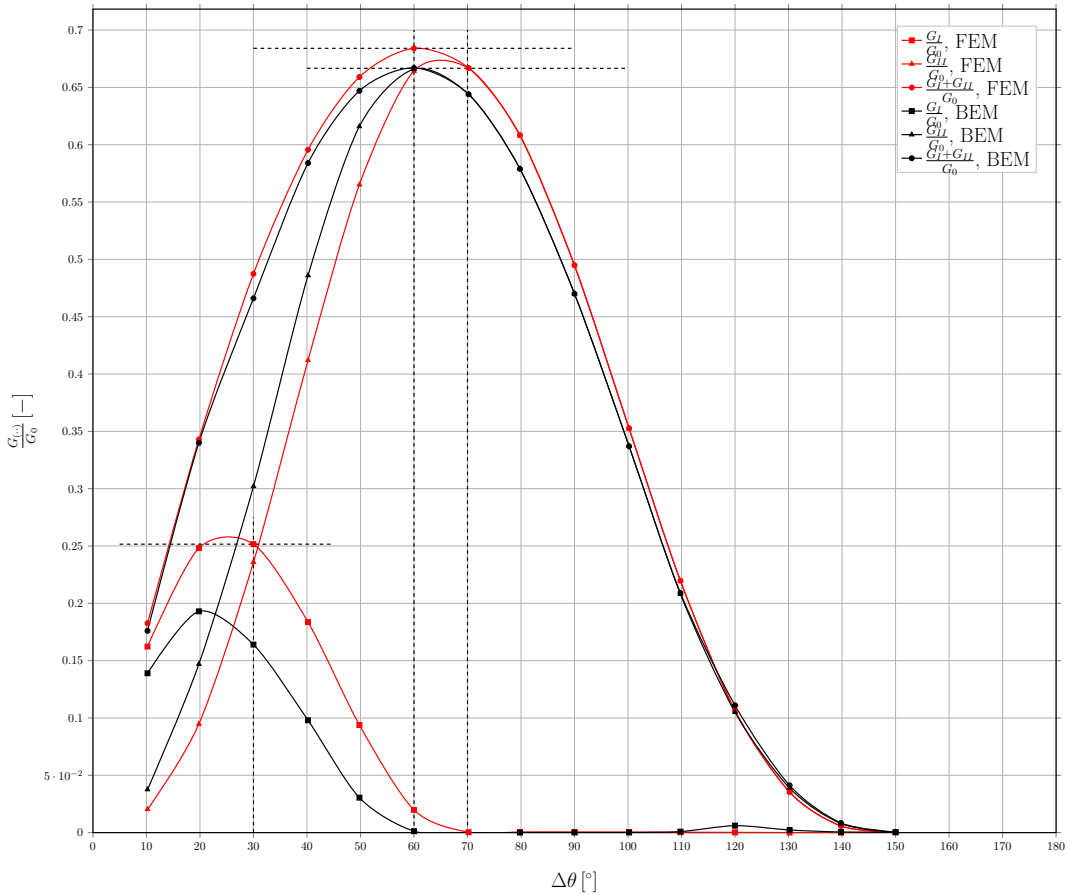
$\delta = .^\circ$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



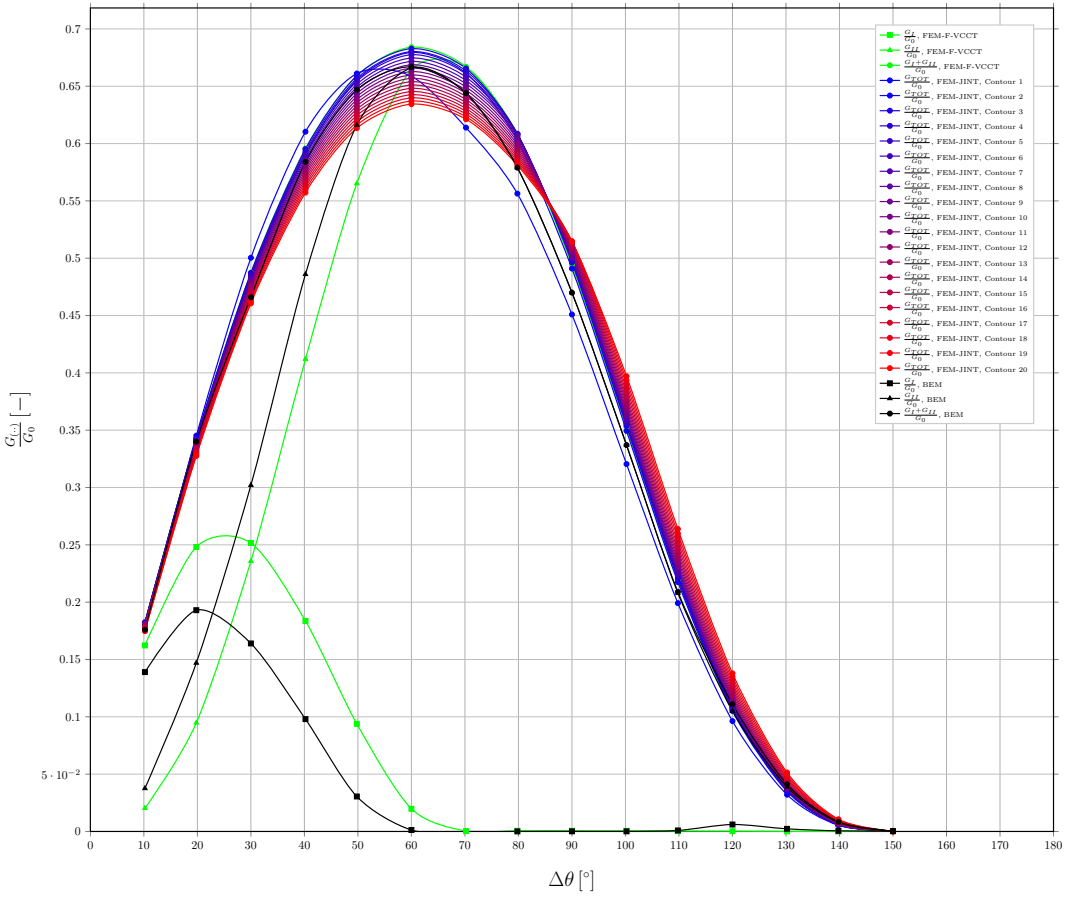
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

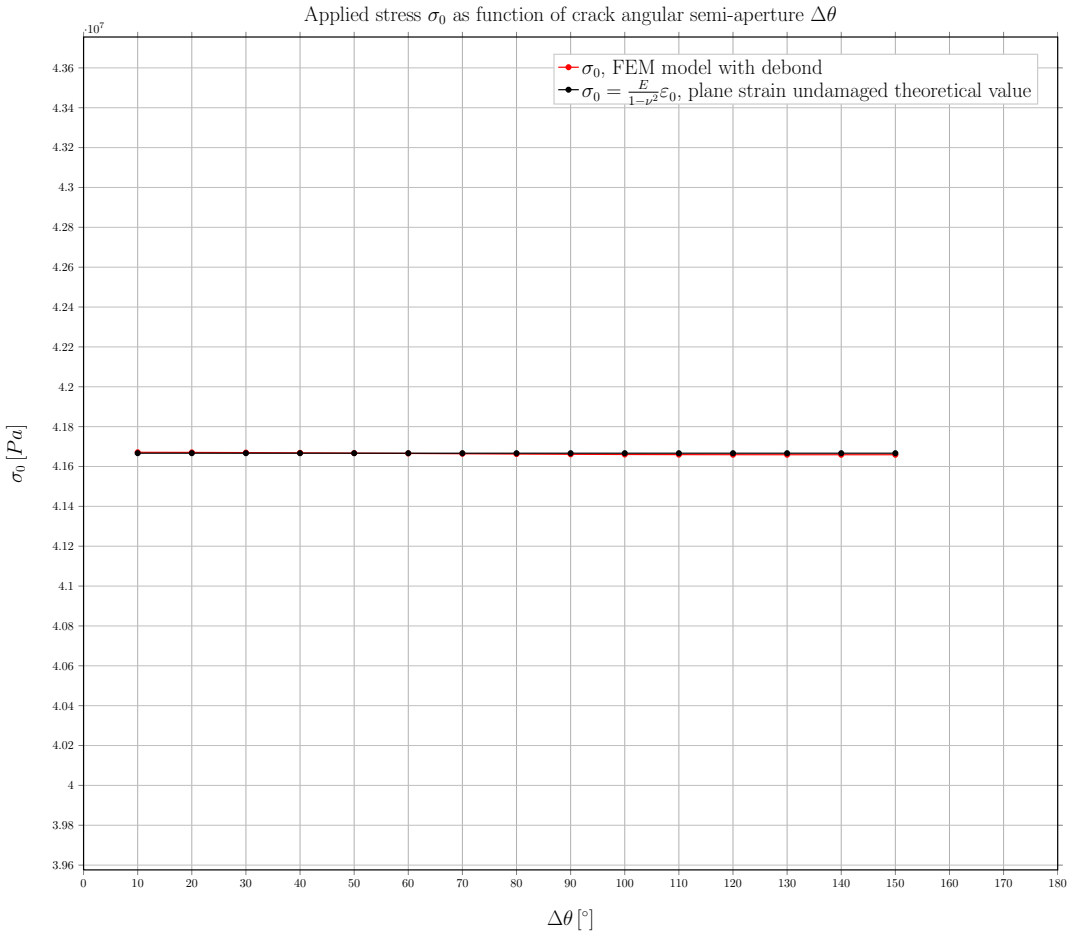


$\delta = .^\circ$

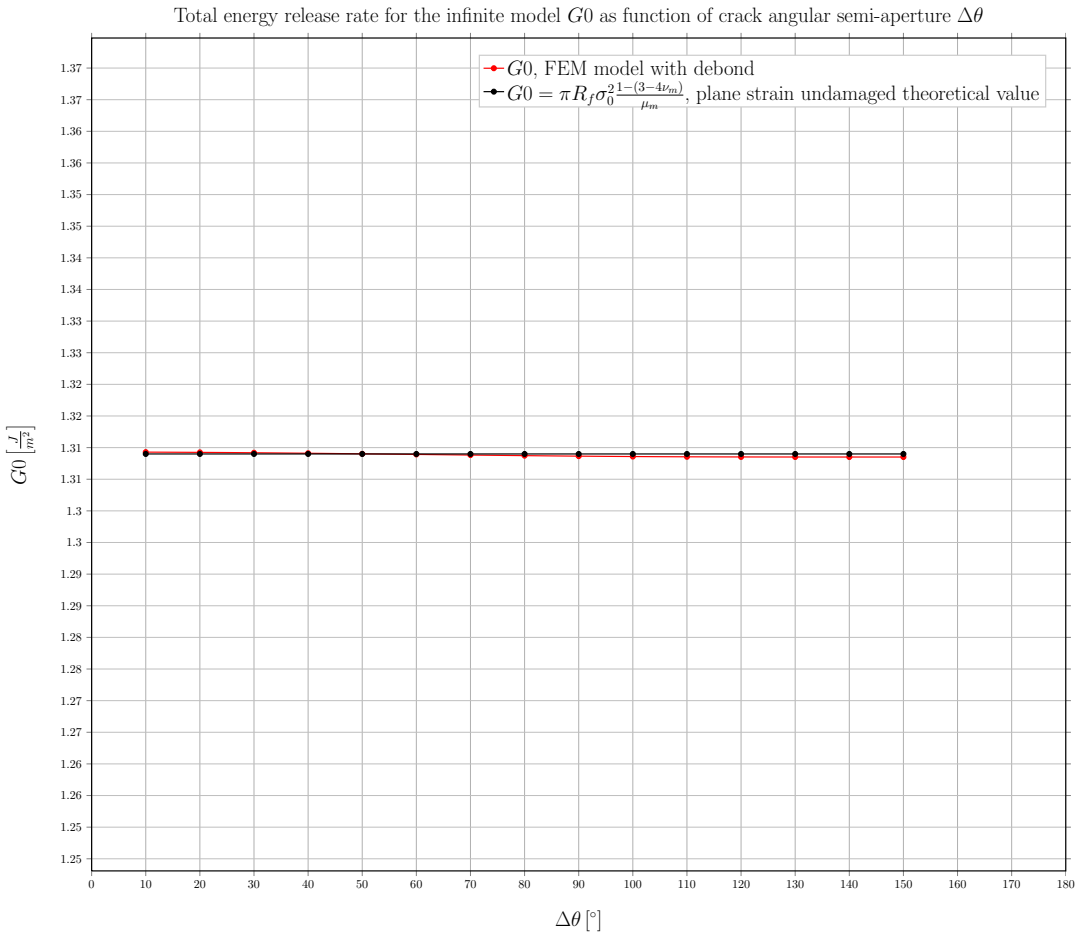
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^\circ$



$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
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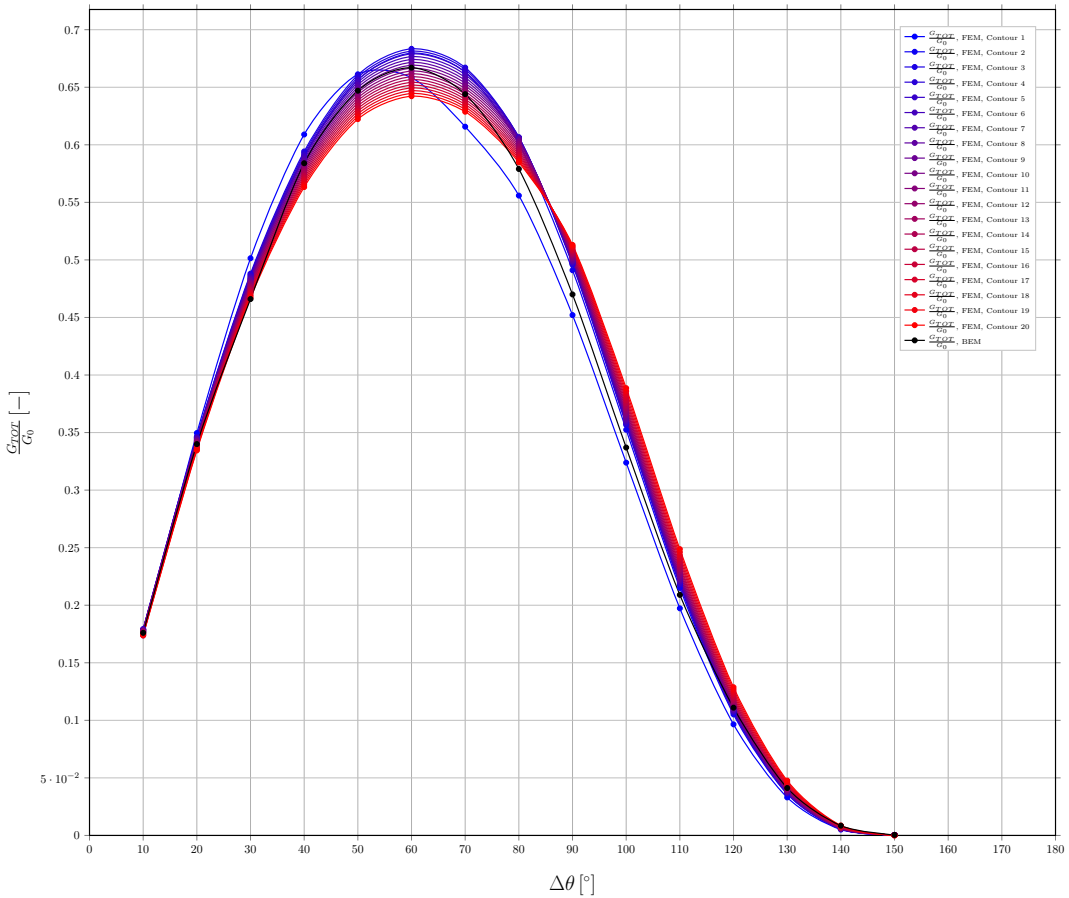
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

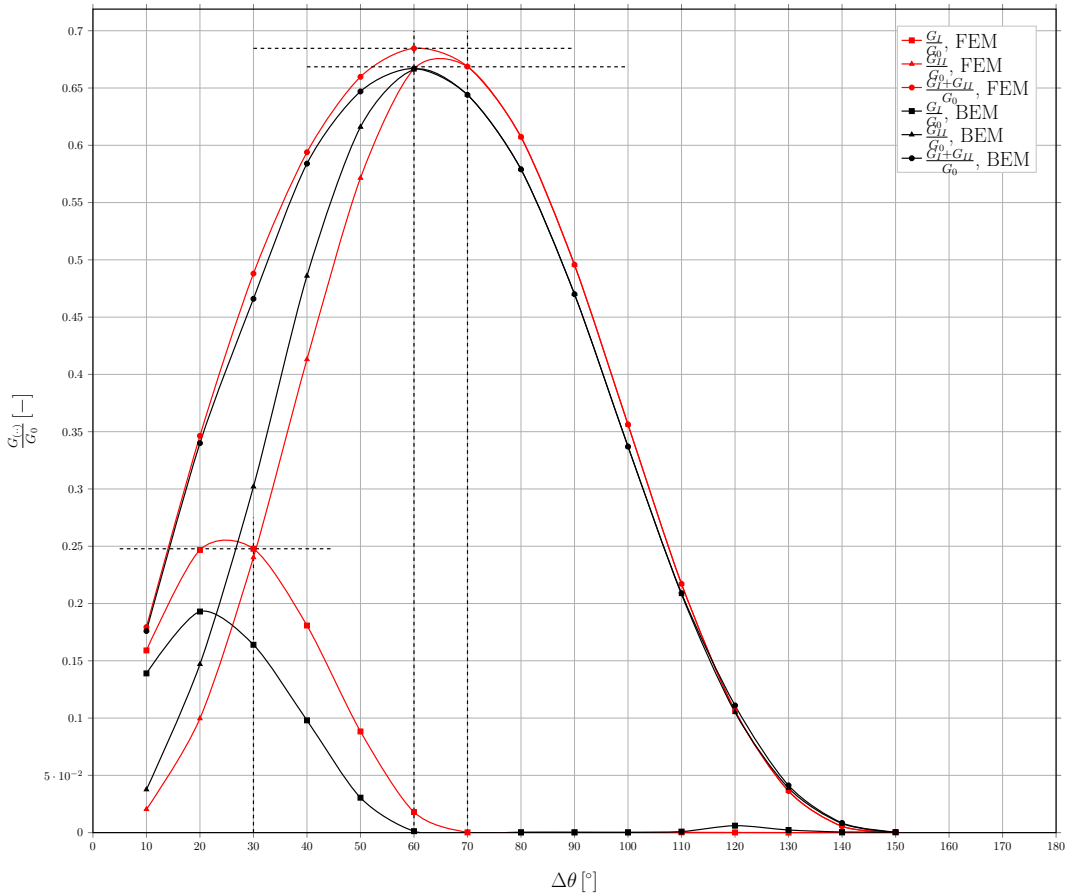
$\delta = .^\circ$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



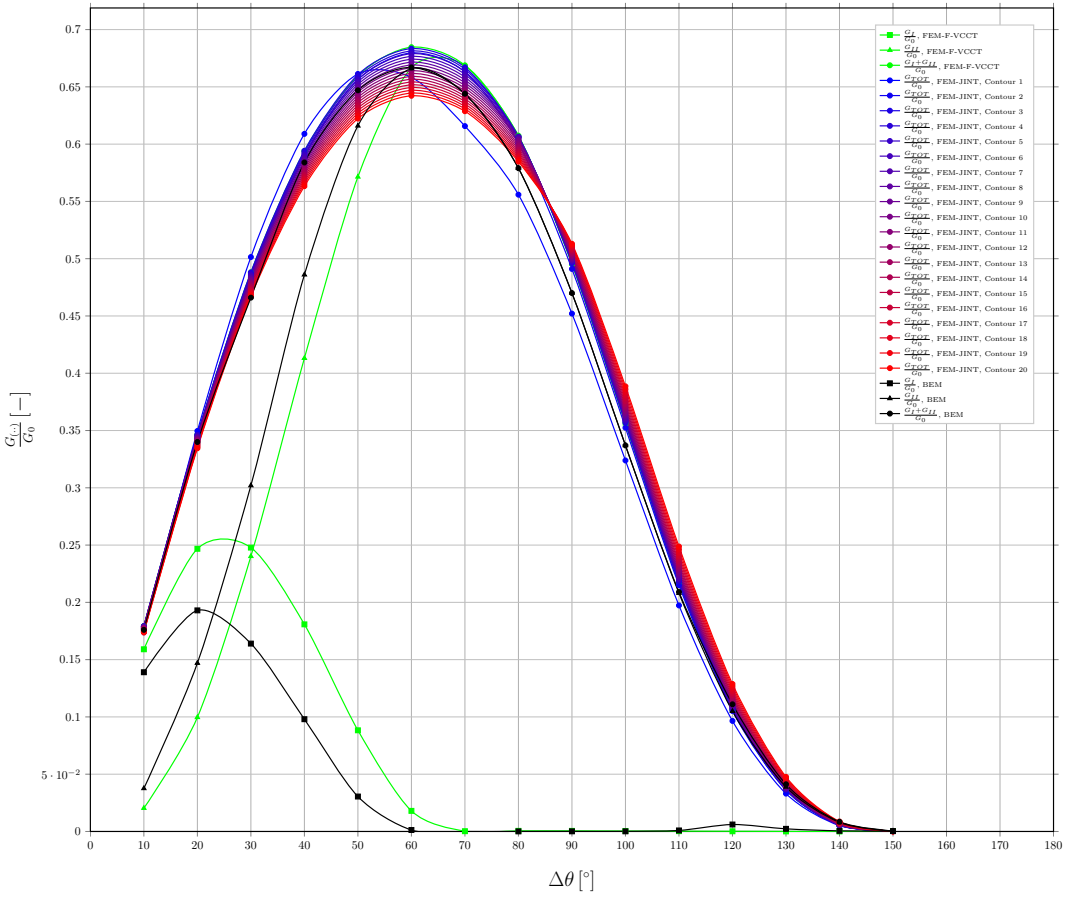
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

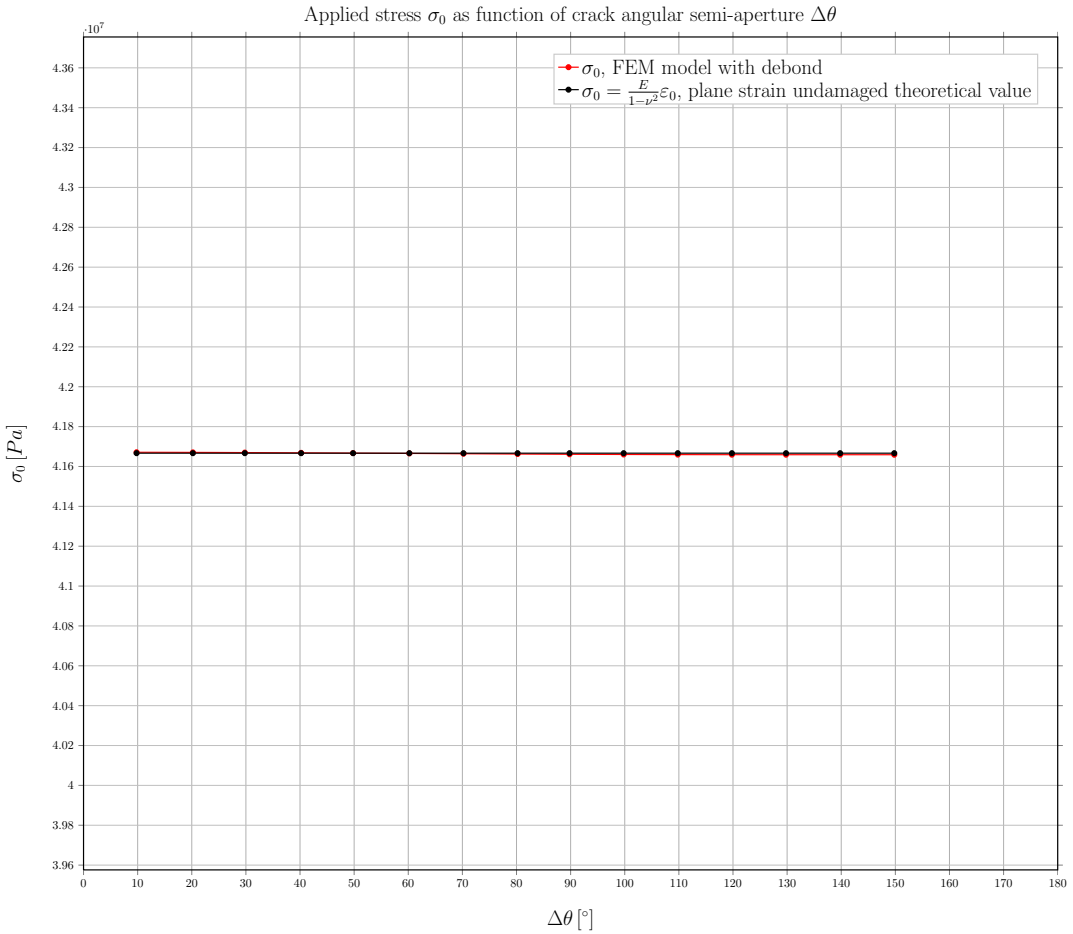


$\delta = .^{\circ}$

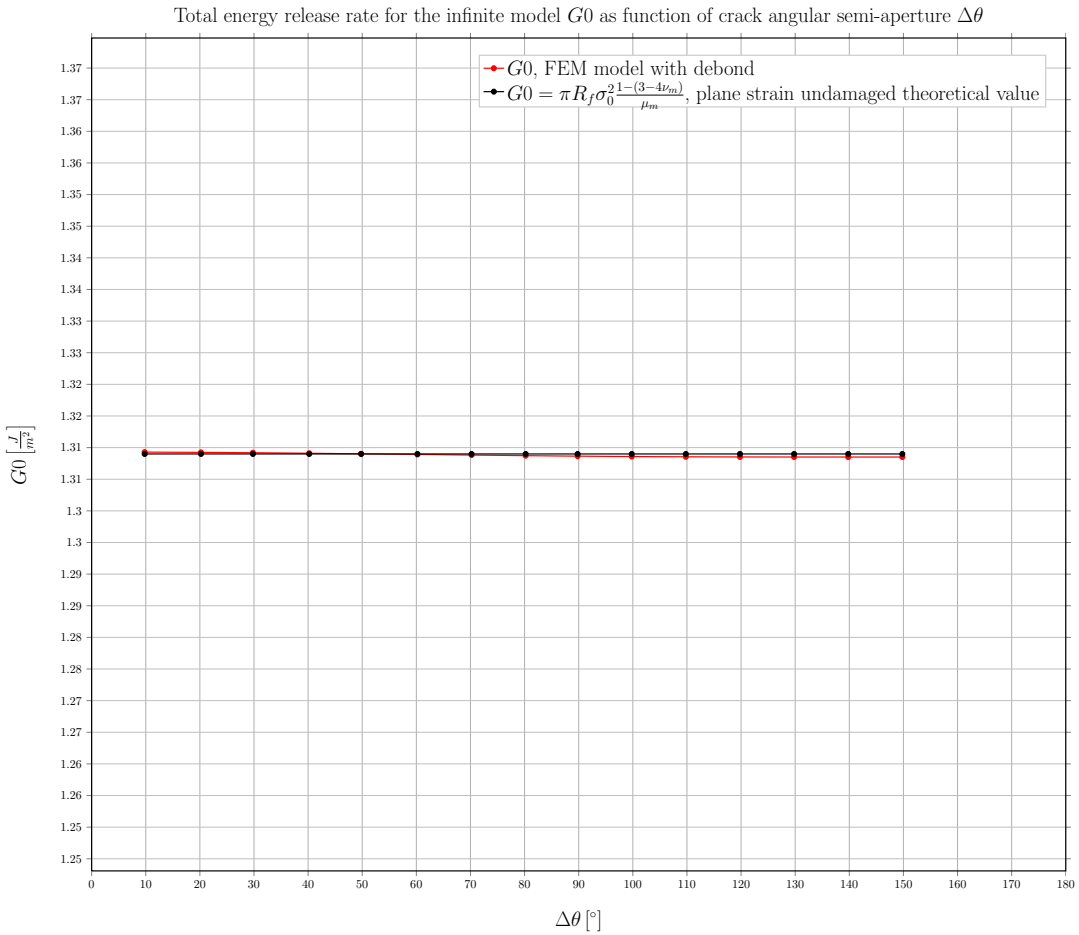
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^\circ$



$\delta = .^{\circ}$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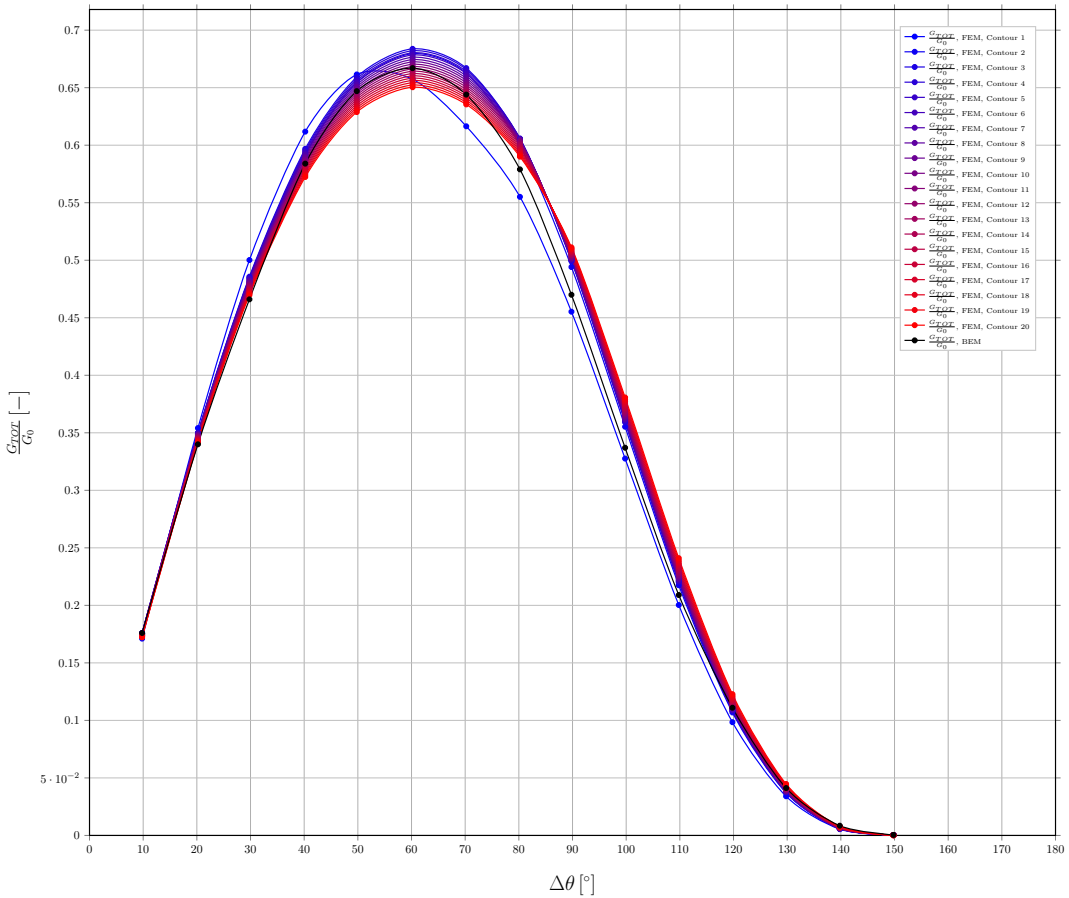
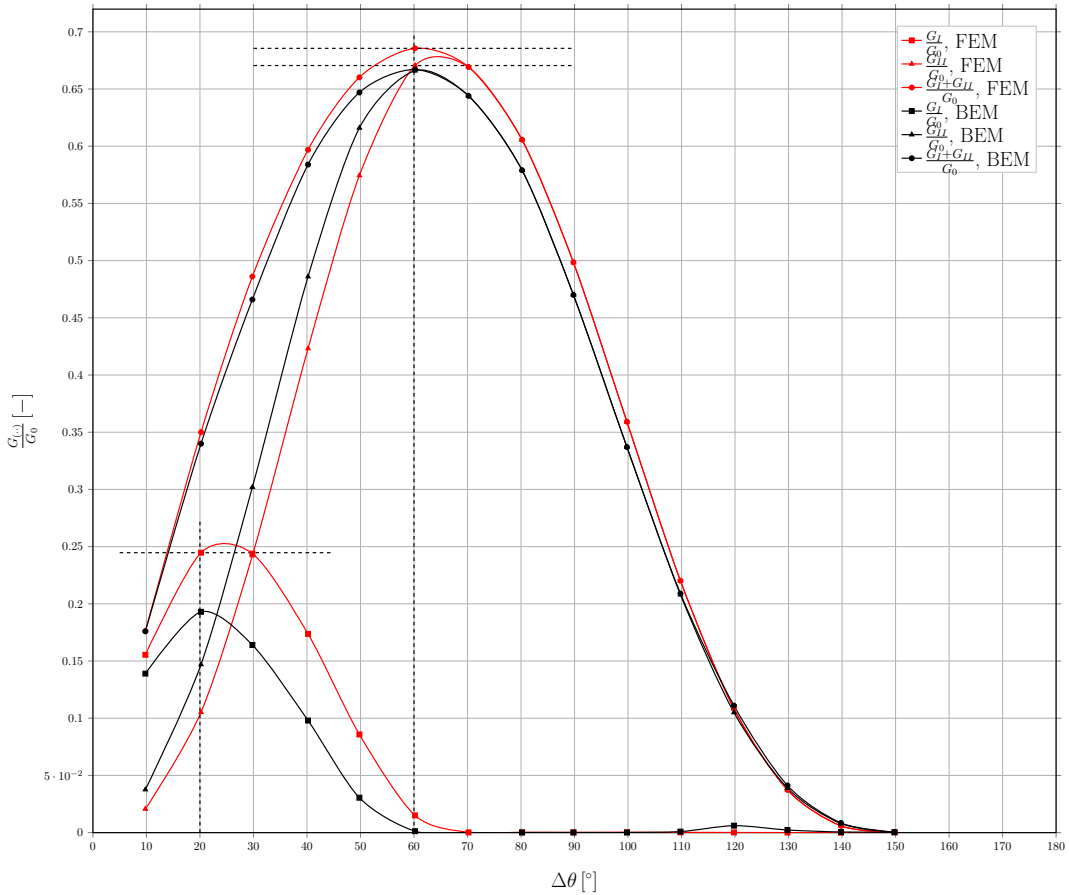
$\delta = .^\circ$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



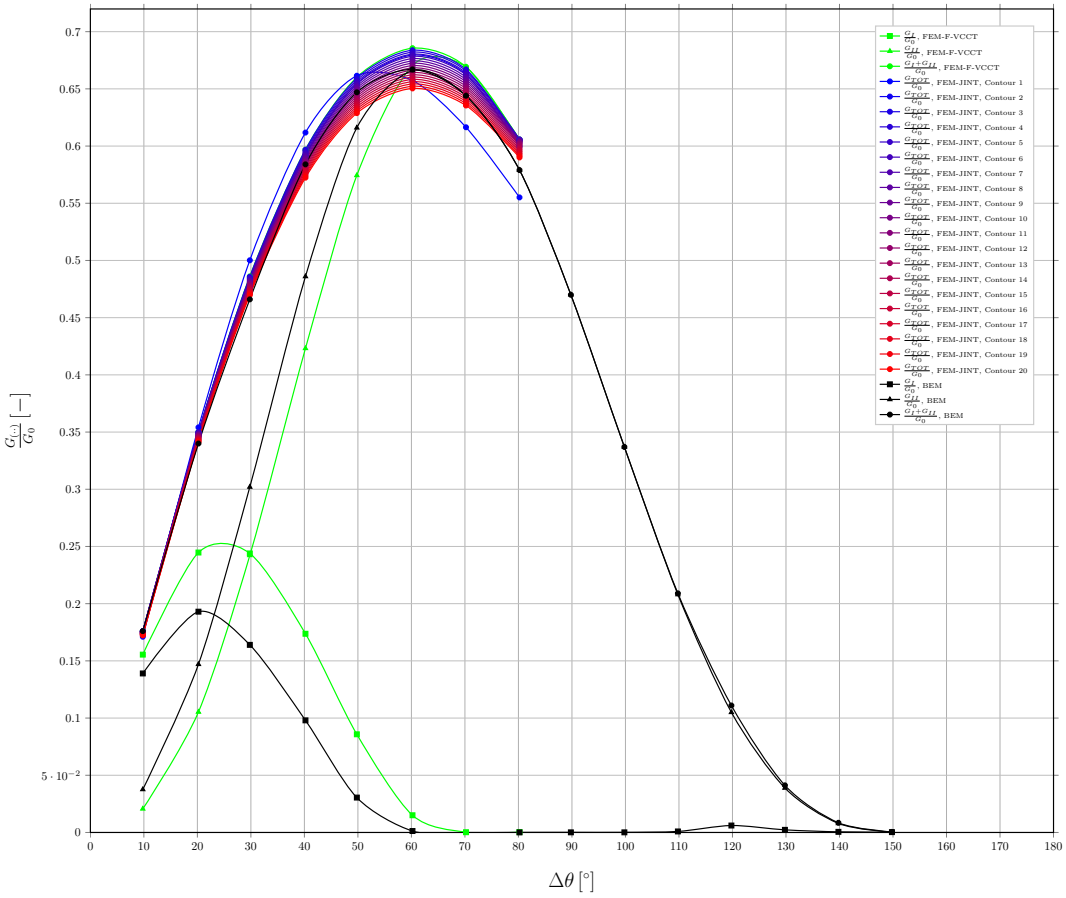
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine

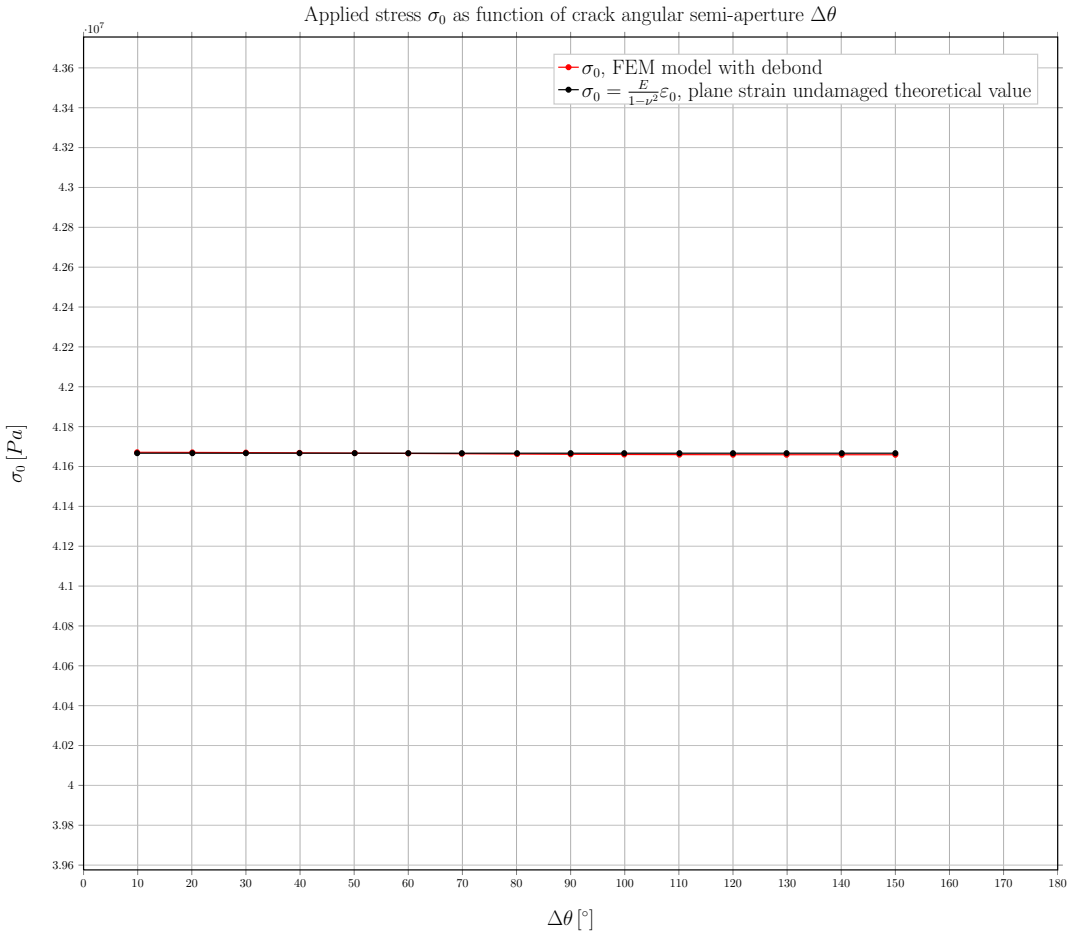


$\delta = .^\circ$

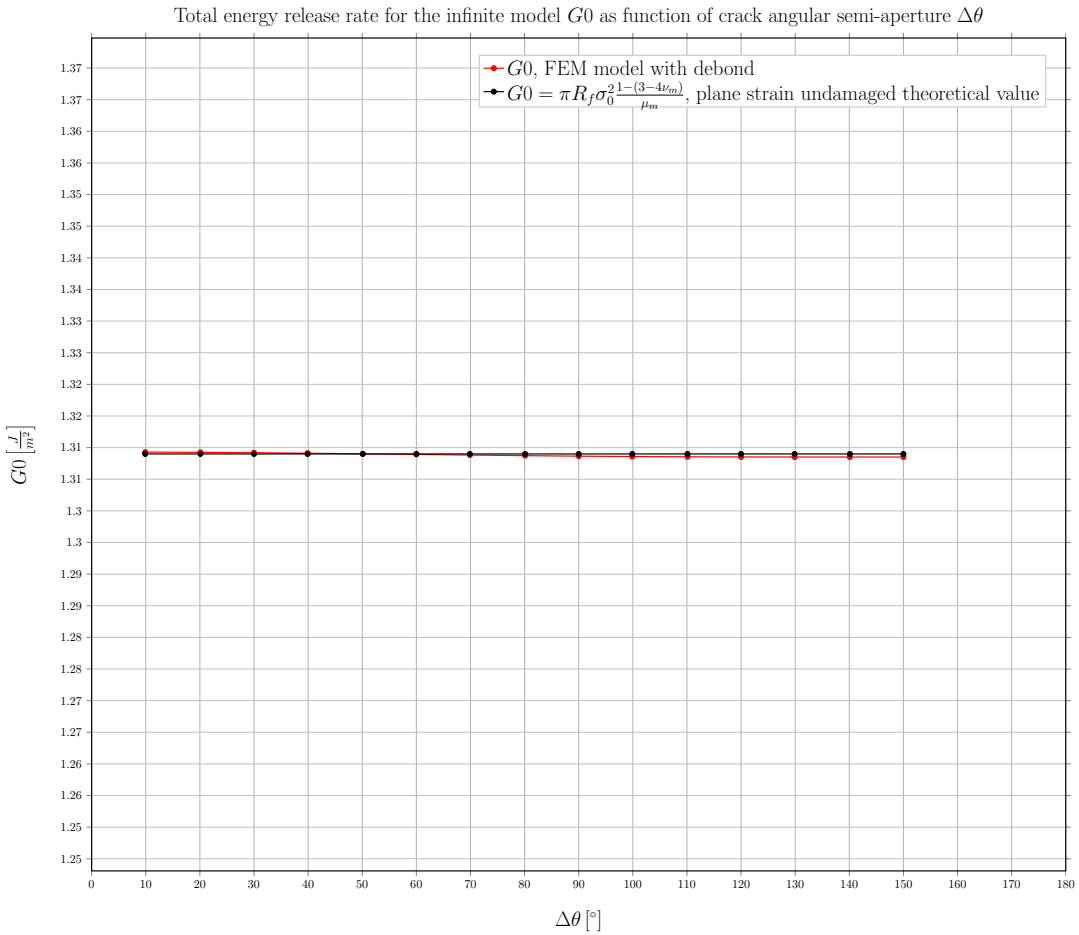
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



$\sigma\delta = .^\circ$

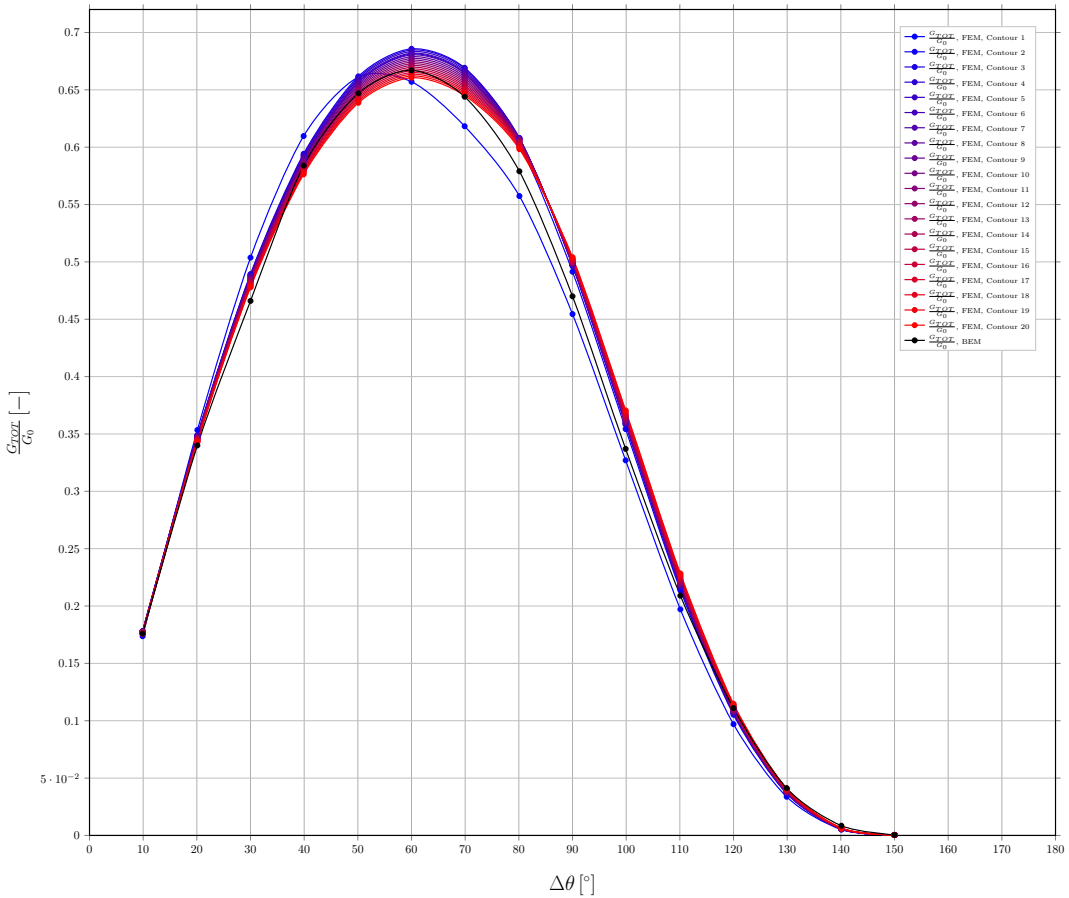


$\delta = .^{\circ}$


Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^{\circ}]$

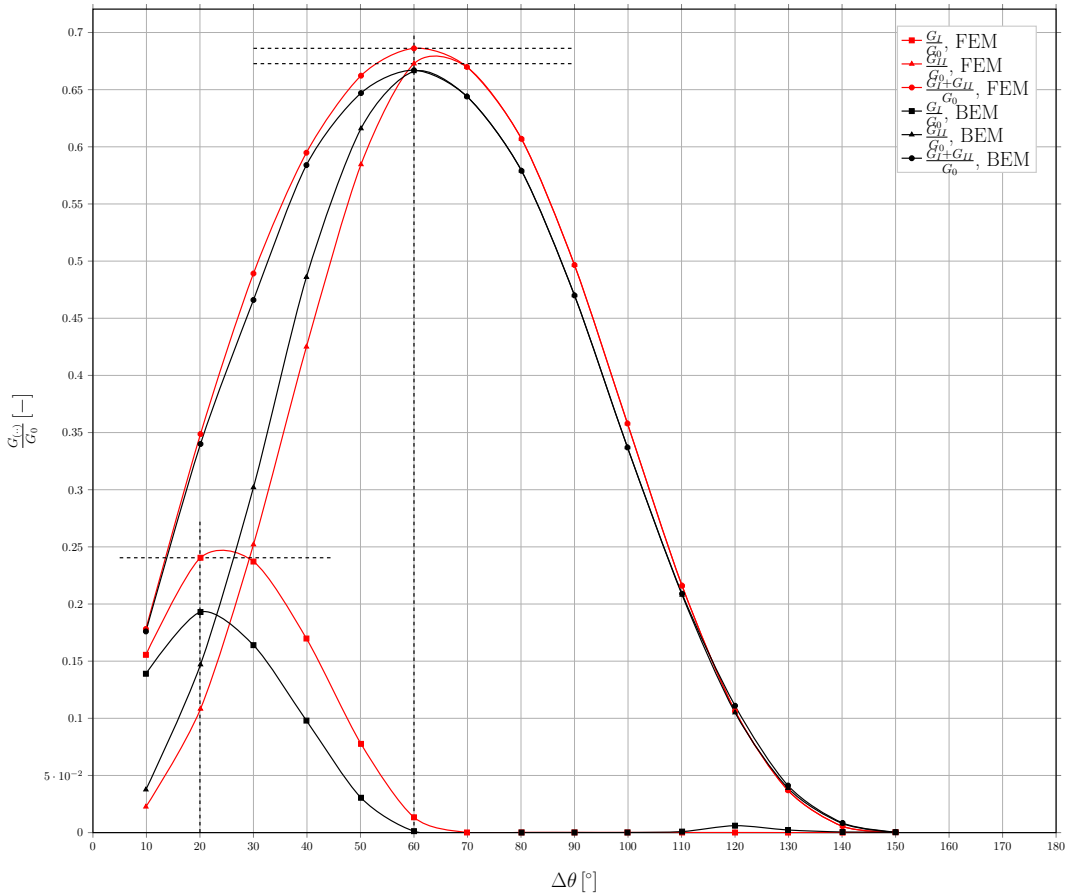
$\delta = .^{\circ}$

Normalized total energy release rate $\frac{G_{TOT}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with Abaqus built-in J-Integral post-processing routine (*CONTOUR INTEGRAL)



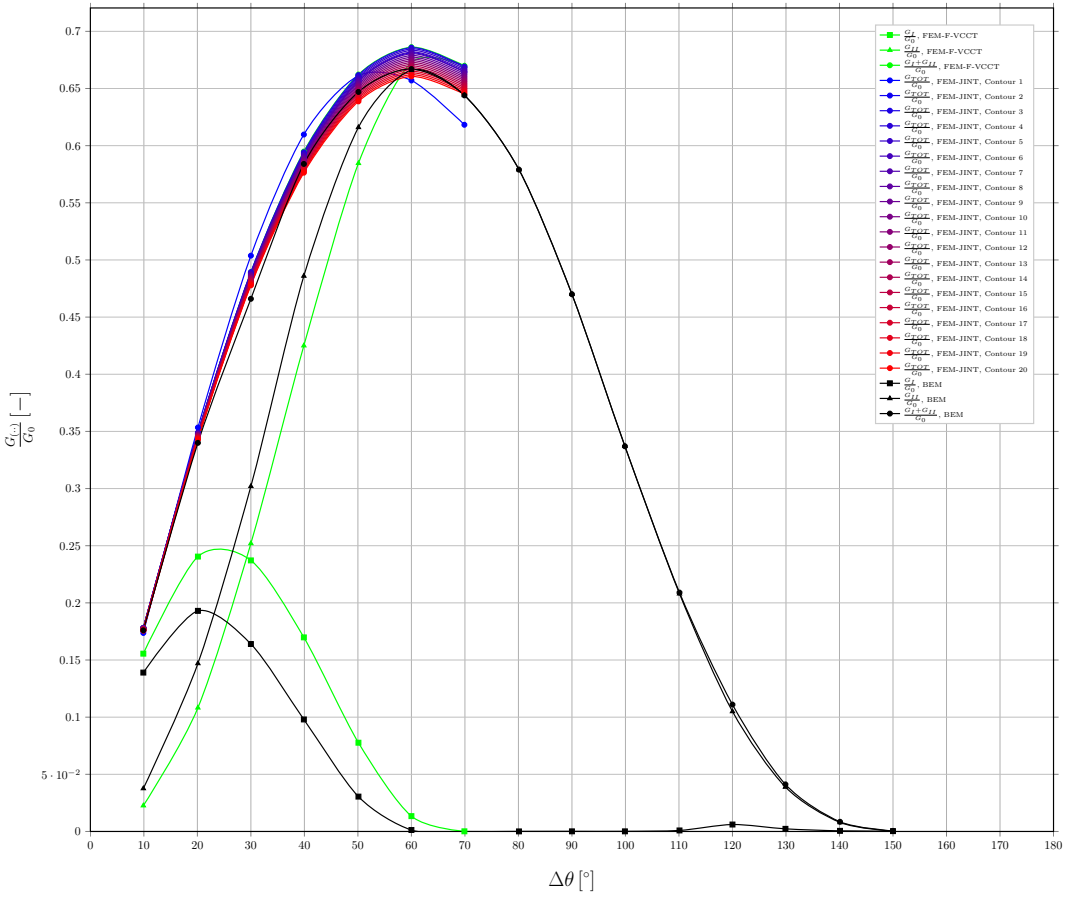
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine



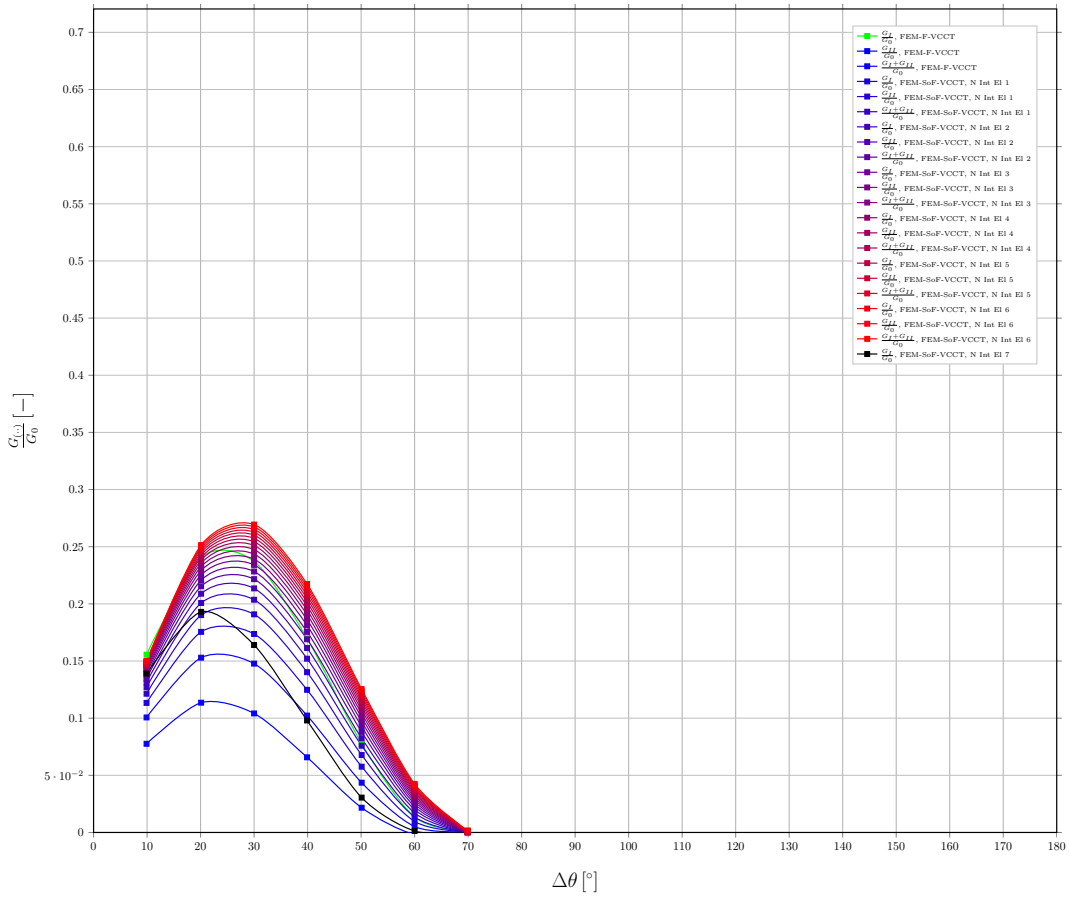
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT and Abaqus built-in J-Integral (*CONTOUR INTEGRAL) post-processing routines



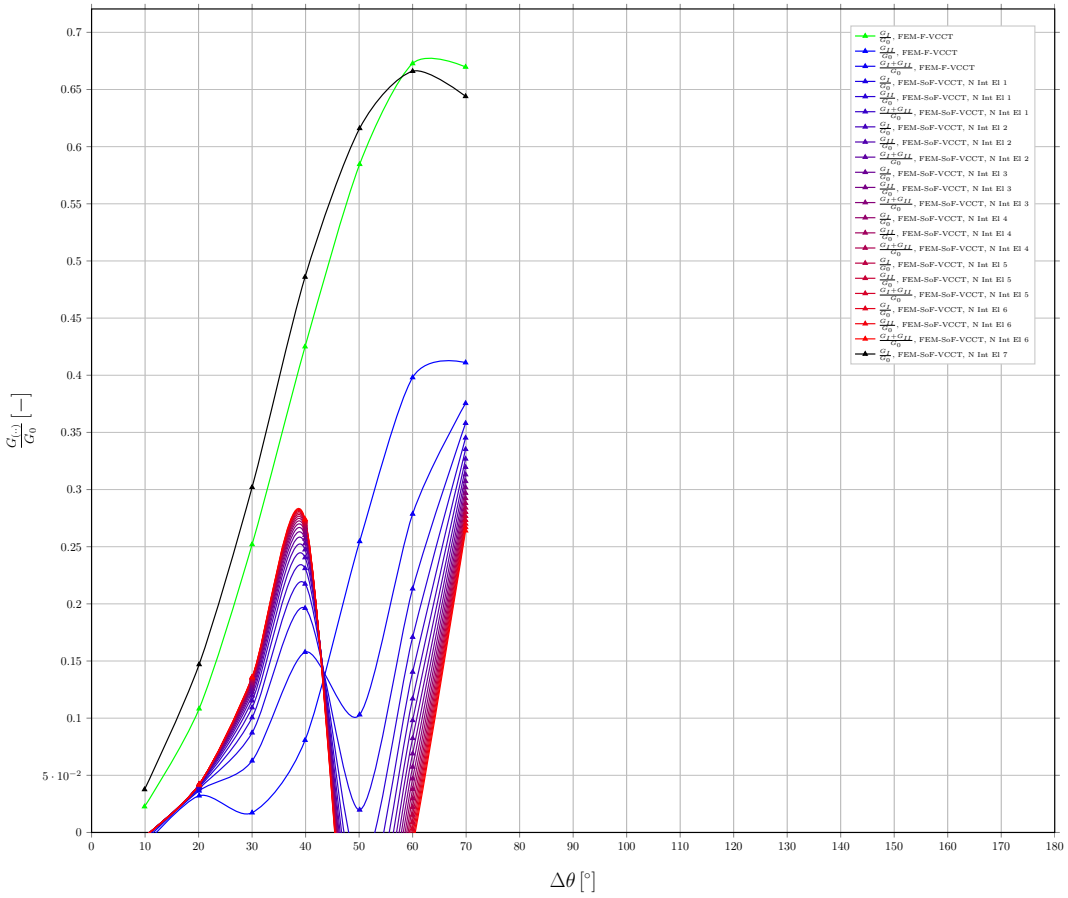
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the fiber side of the interfac



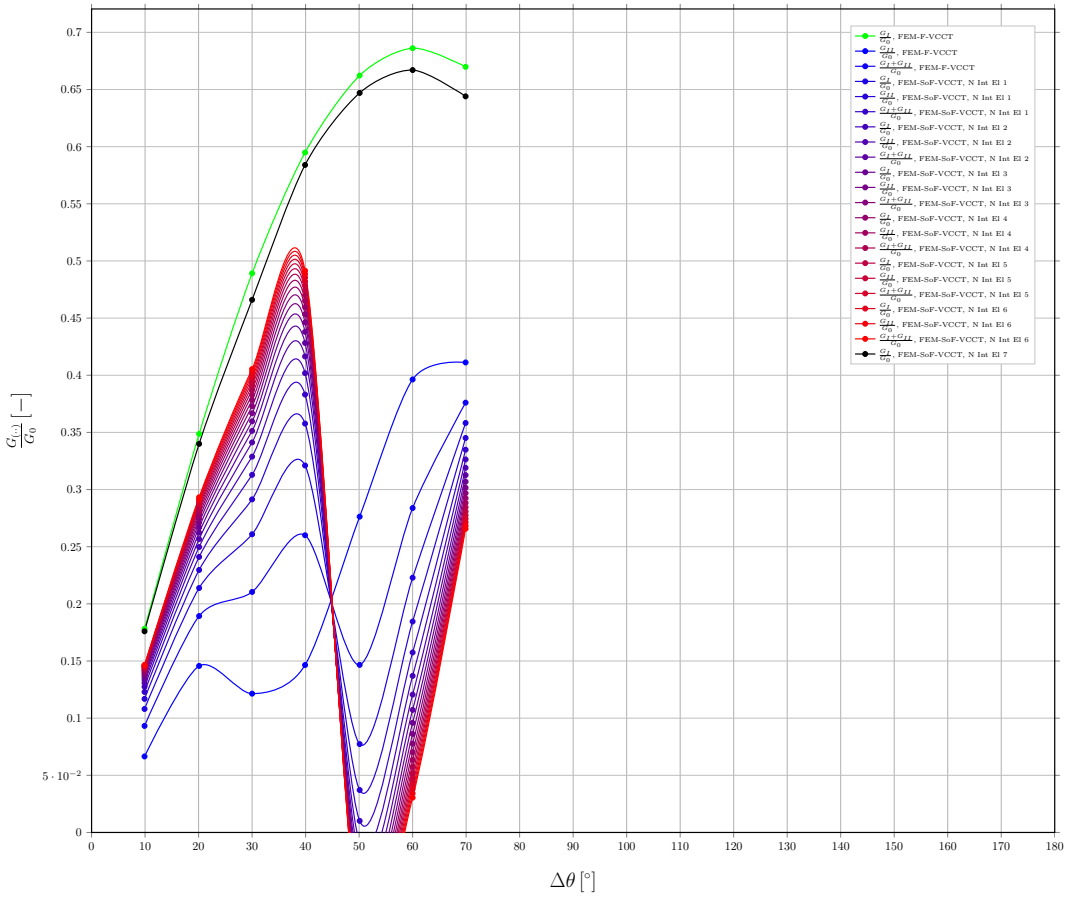
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the fiber side of the interfac



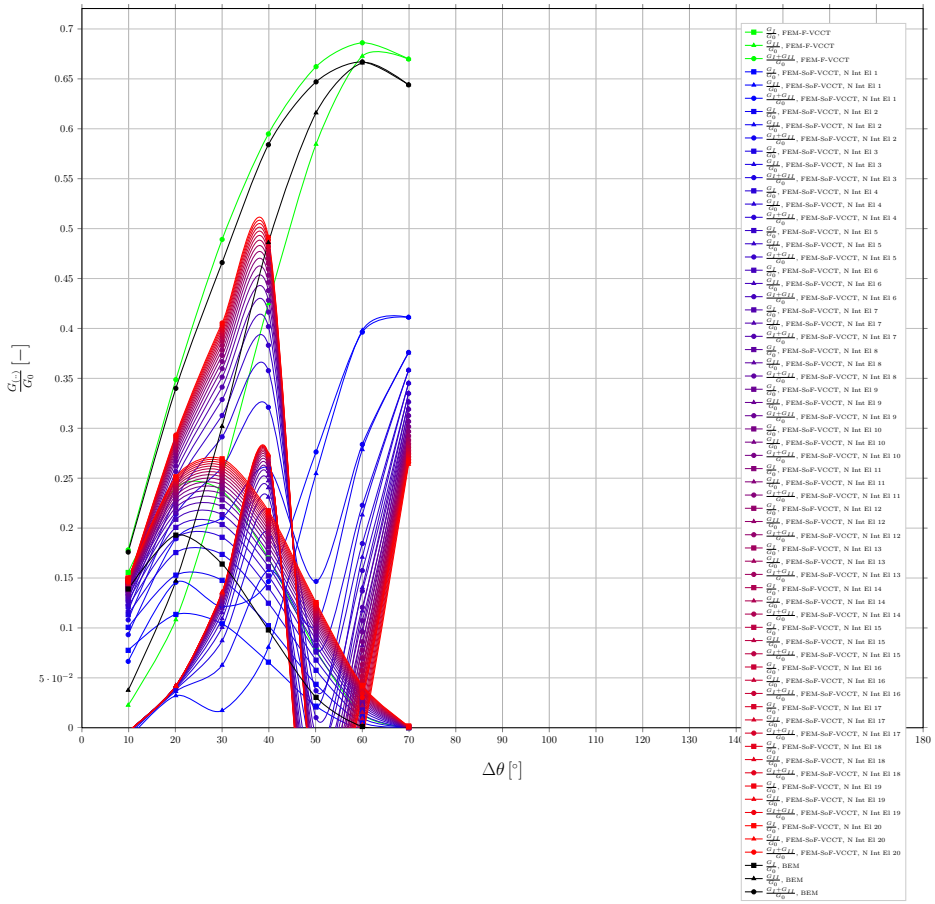
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the fiber side of the interfac



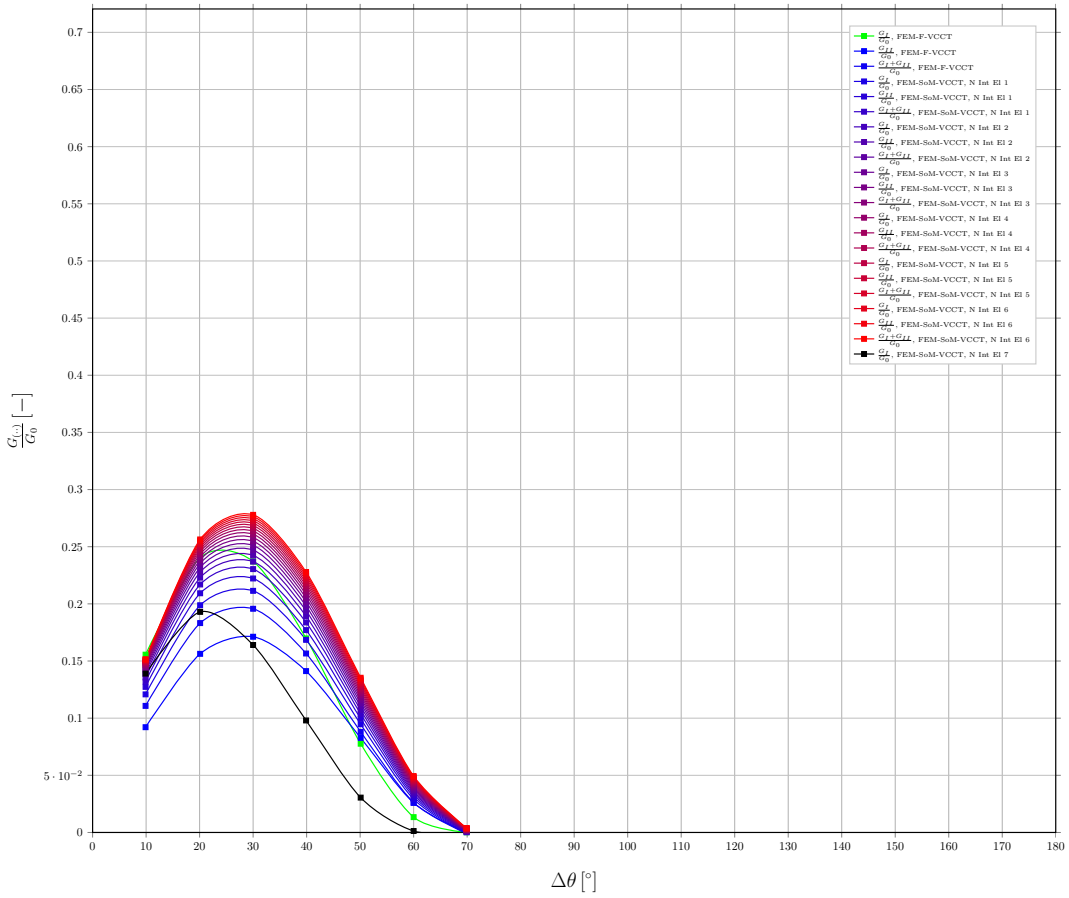
$(\cdot\cdot)^{\delta = .^{\circ}}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the fiber side of the interface



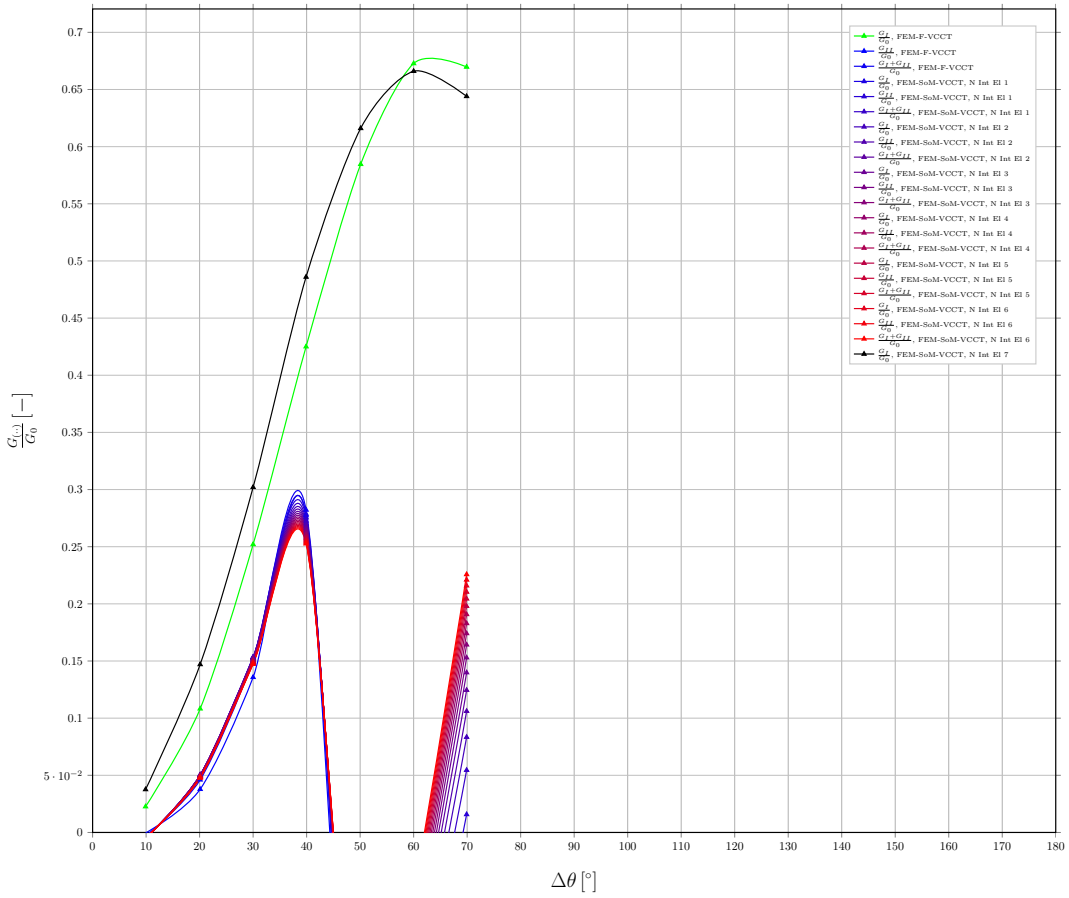
$\delta = .^{\circ}$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the matrix side of the interf



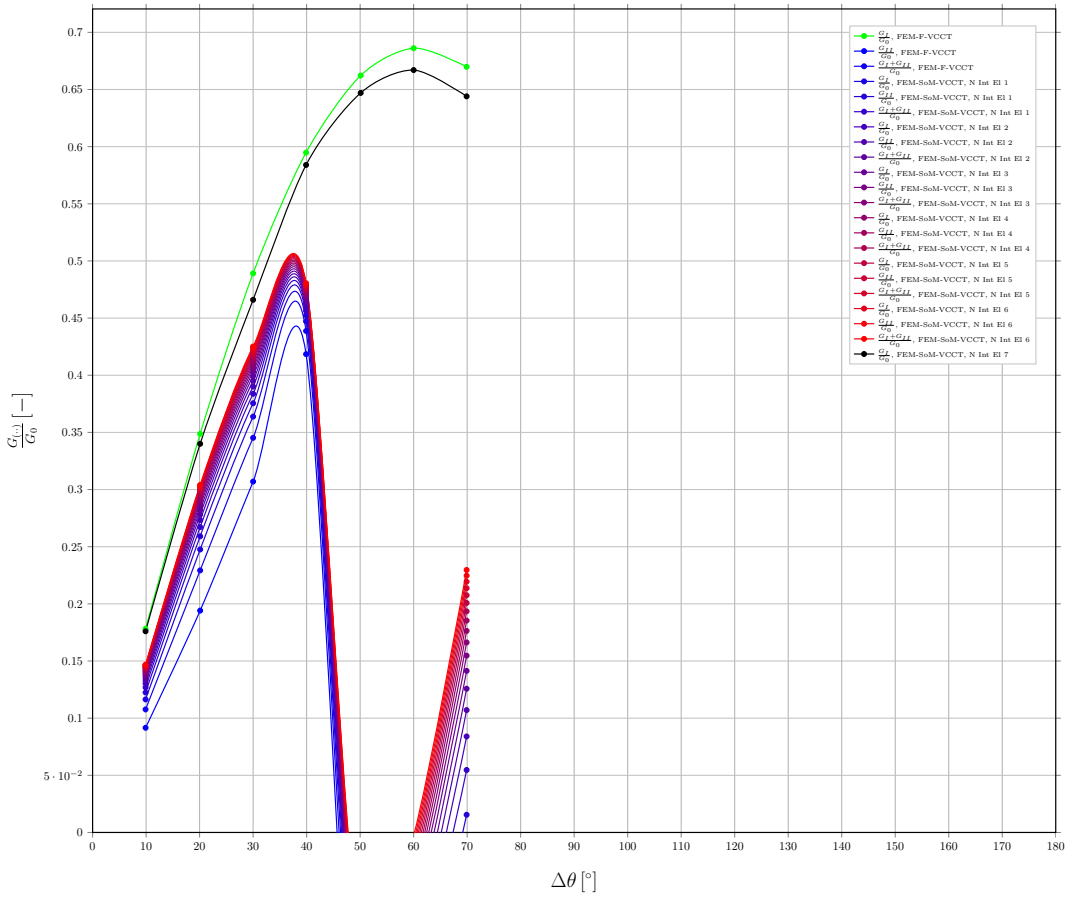
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the matrix side of the interf



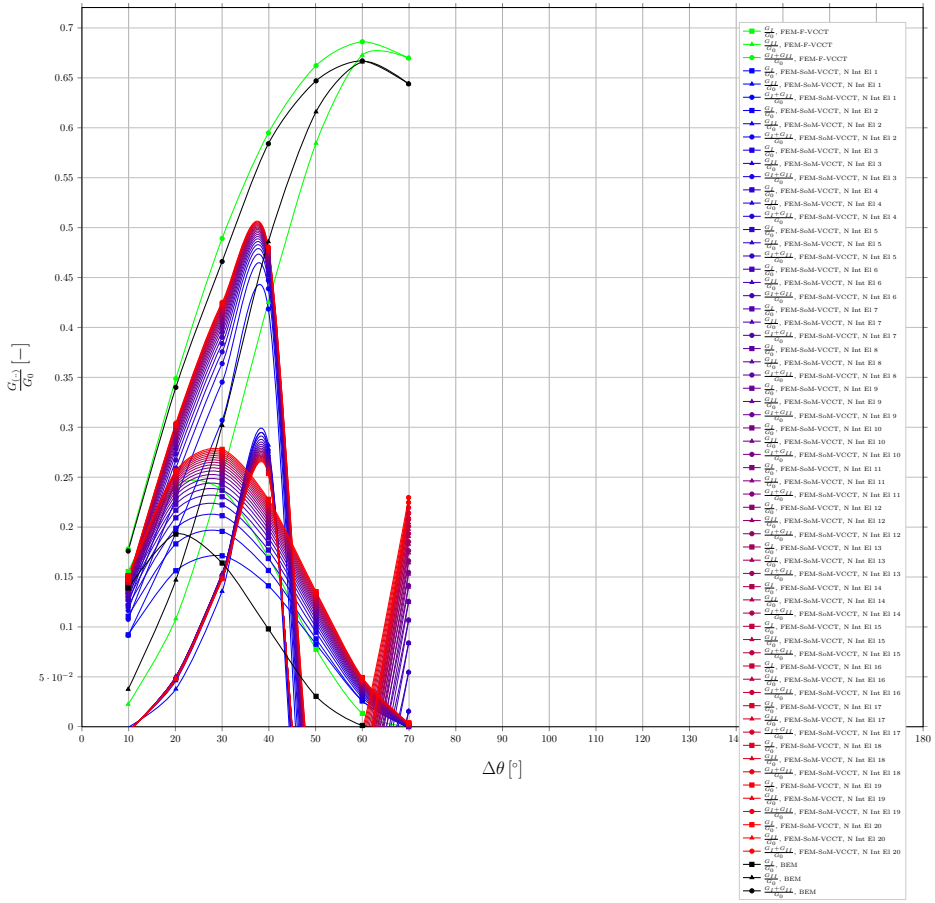
$\delta = .^\circ$

Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the matrix side of the interf

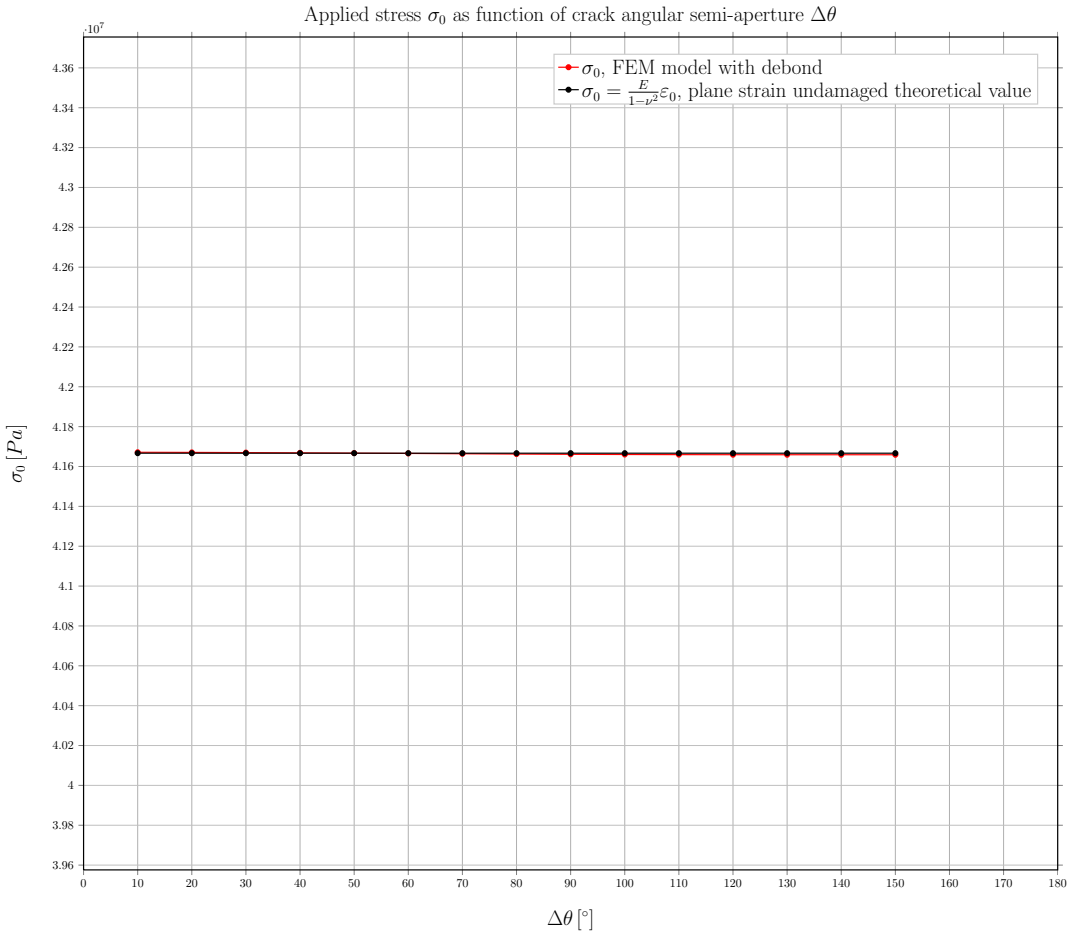


$(\cdot\cdot)^{\delta} = .^{\circ}$

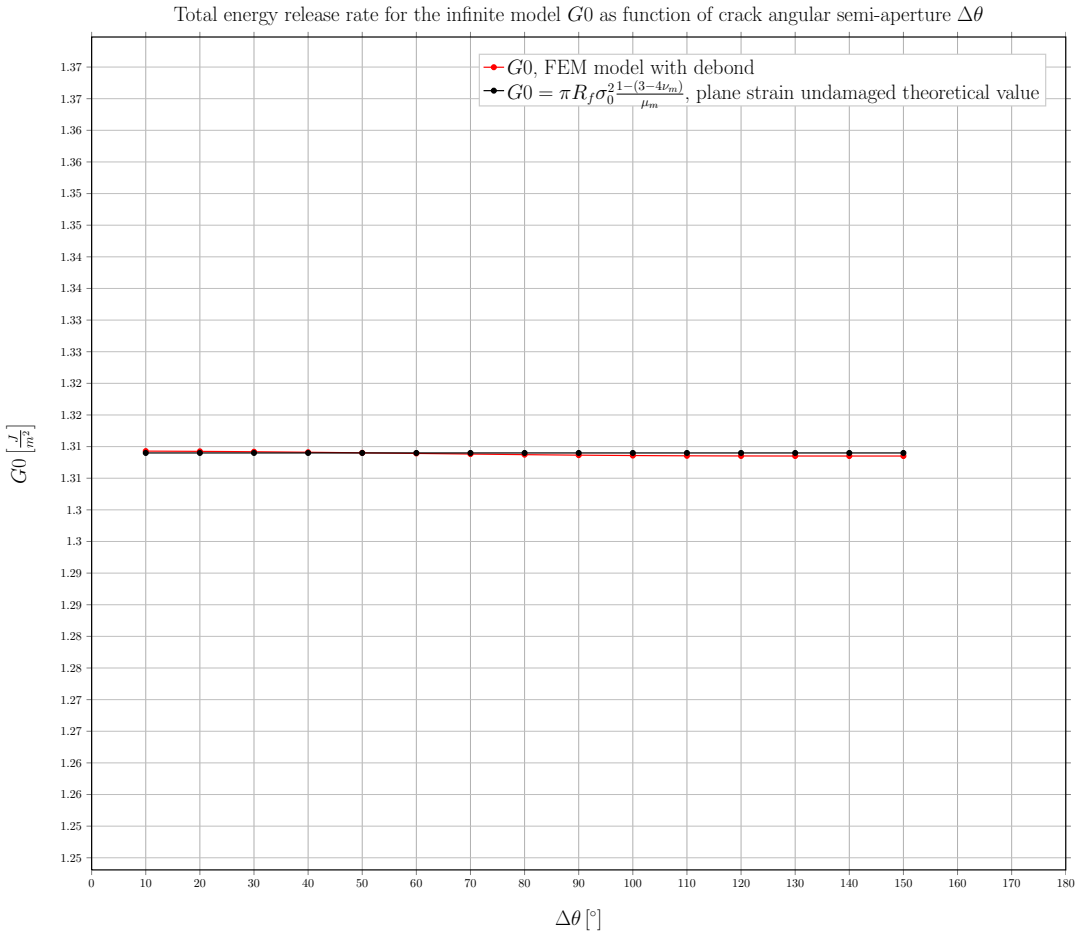
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based and stress-based VCCT post-processing routines with stresses extracted on the matrix side of the interface



$\sigma\delta = .^\circ$

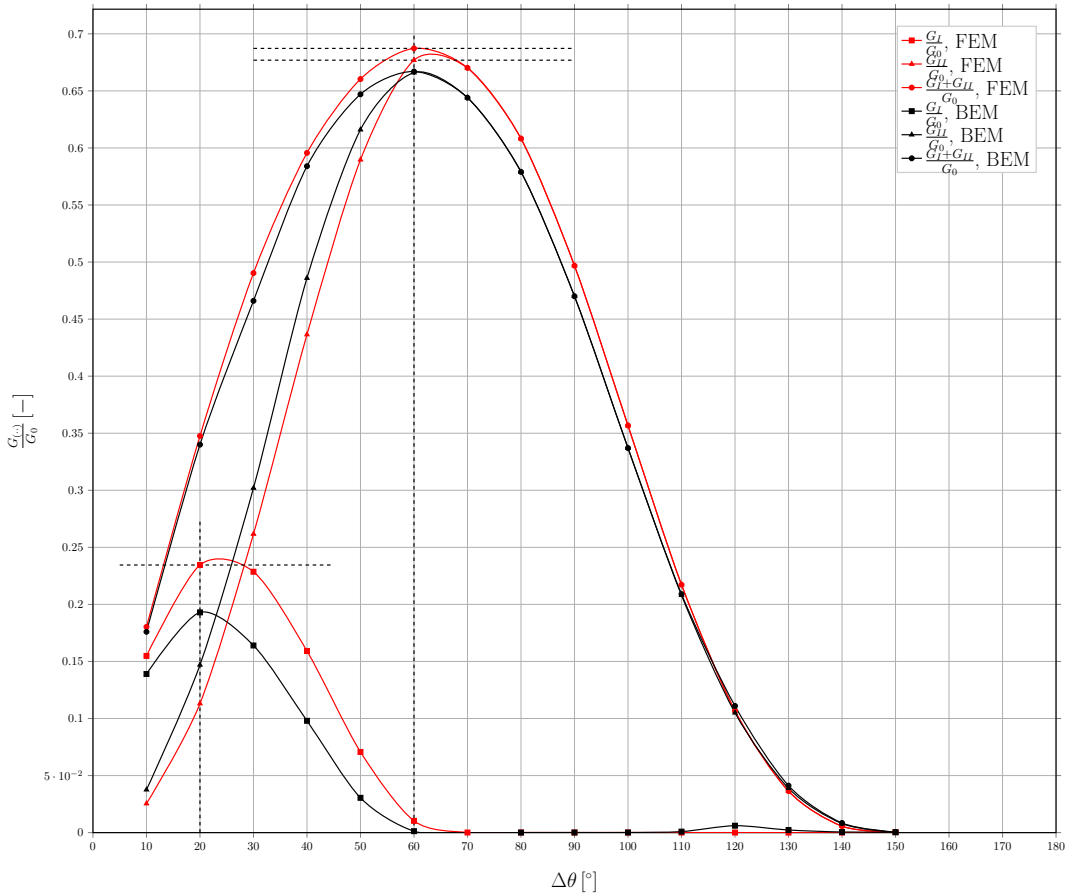


$\delta = .^\circ$

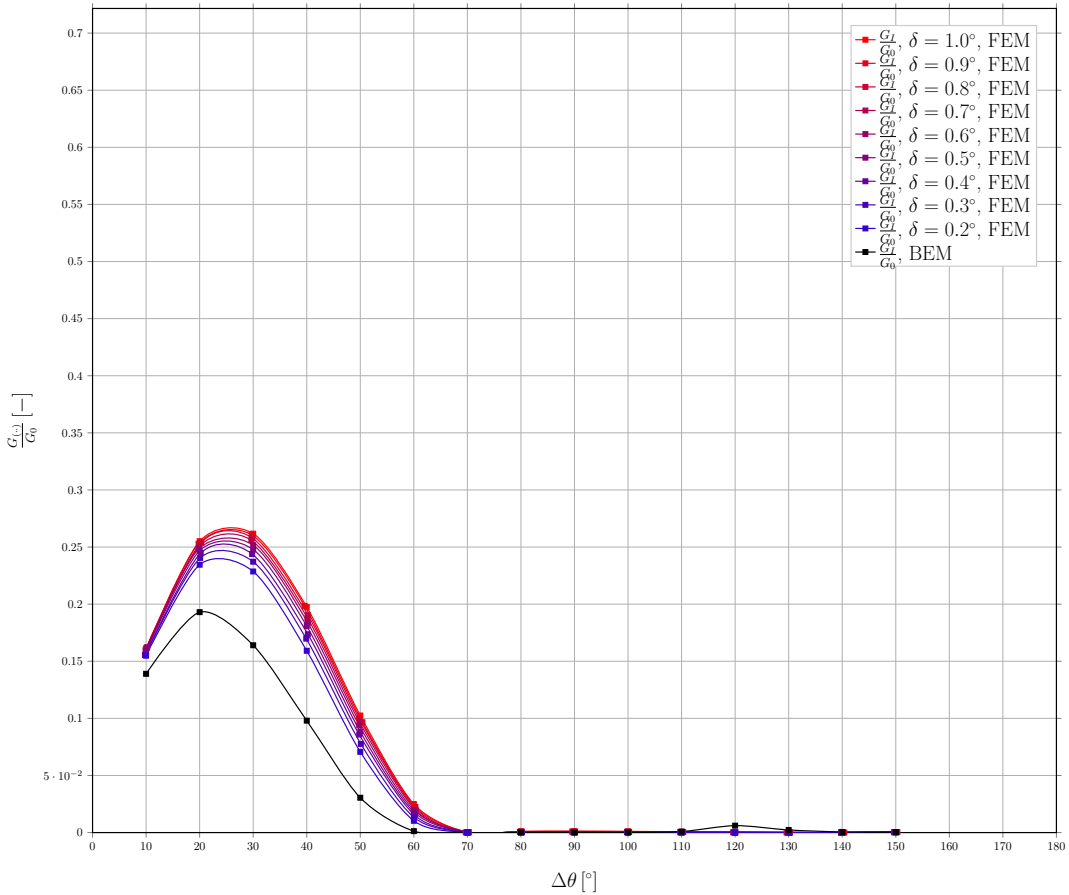

Total energy release rate for the infinite model $G0$ as function of crack angular semi-aperture $\Delta\theta$
$G0$, FEM model with debond
$G0 = \pi R_f \sigma_0^2 \frac{1-(3-4\nu_m)}{\mu_m}$, plane strain undamaged theoretical value
$G0\ [\frac{J}{m^2}]$
$\Delta\theta\ [^\circ]$
1.37
1.37
1.36
1.36
1.35
1.35
1.34
1.34
1.33
1.33
1.32
1.32
1.31
1.31
1.3
1.3
1.29
1.29
1.28
1.28
1.27
1.27
1.26
1.26
1.25
1.25
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

$\delta = .^\circ$

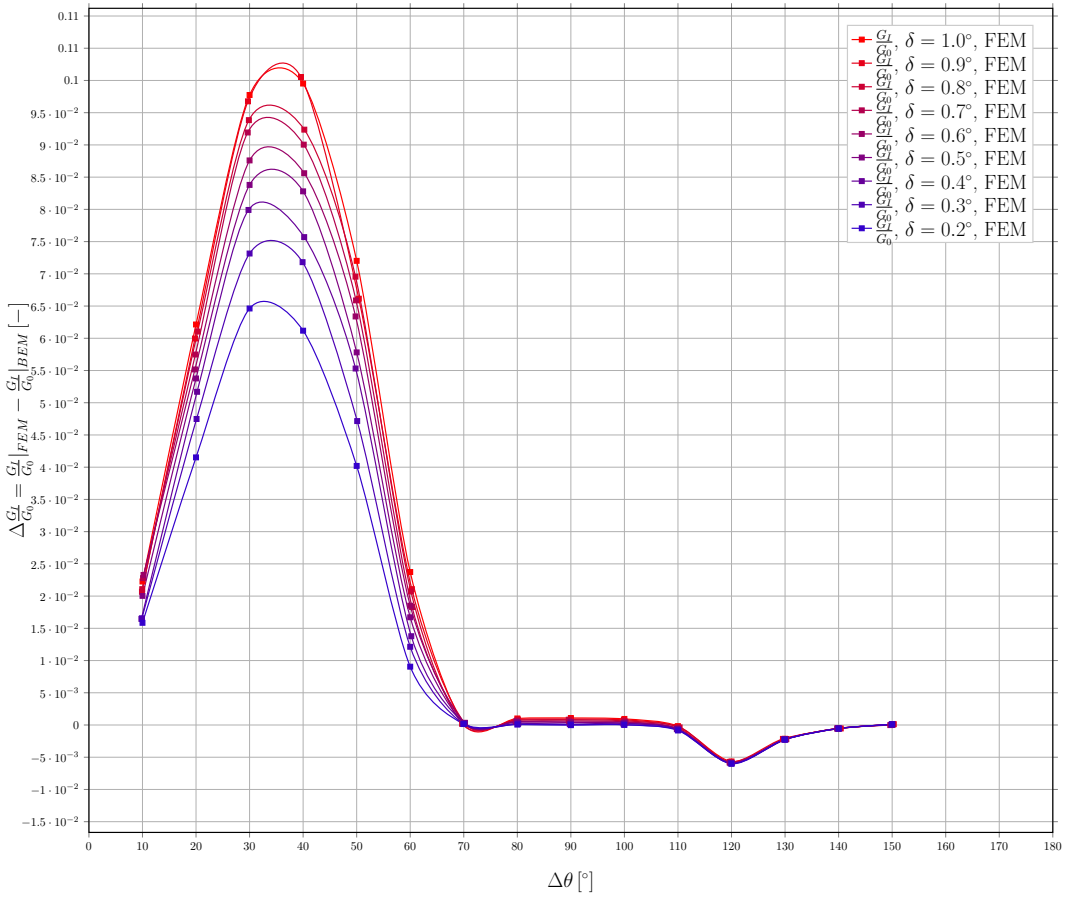
Normalized energy release rate $\frac{G_{(\cdot)}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, calculated with in-house force-based VCCT post-processing routine



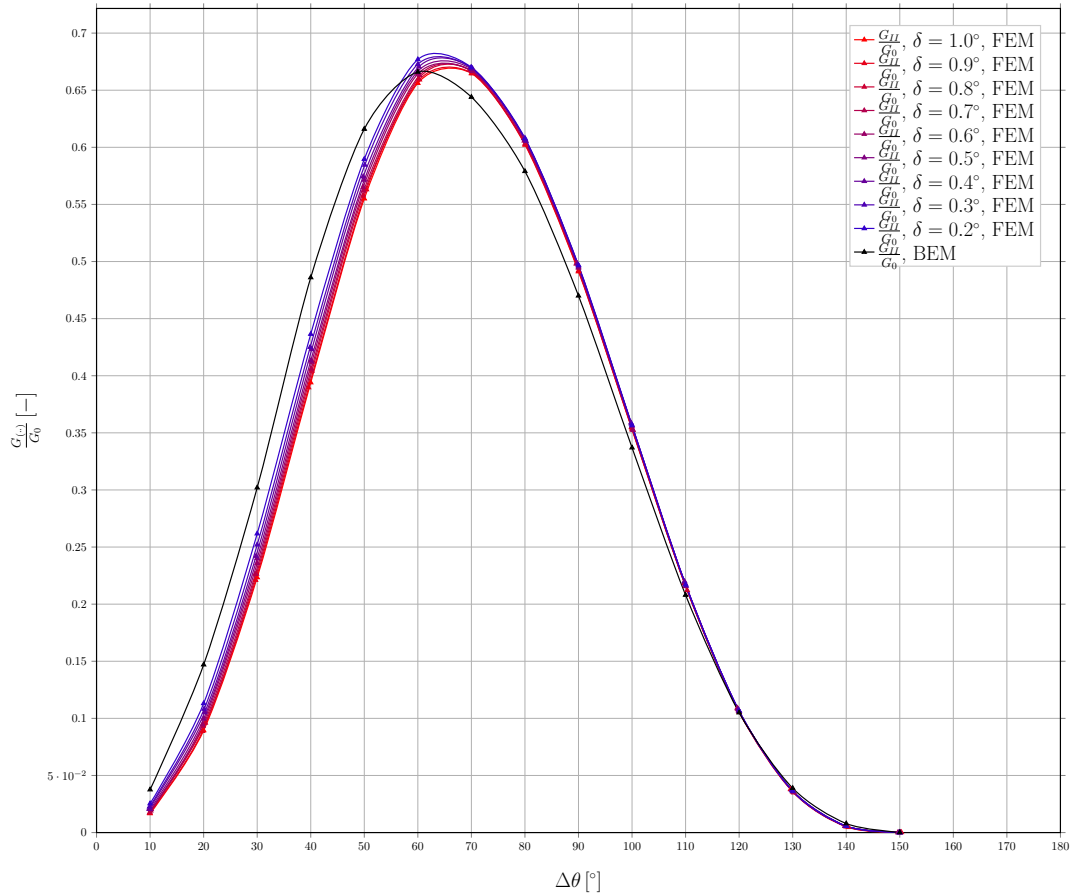
Normalized energy release rate $\frac{G_I}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VCCT post-processing routine



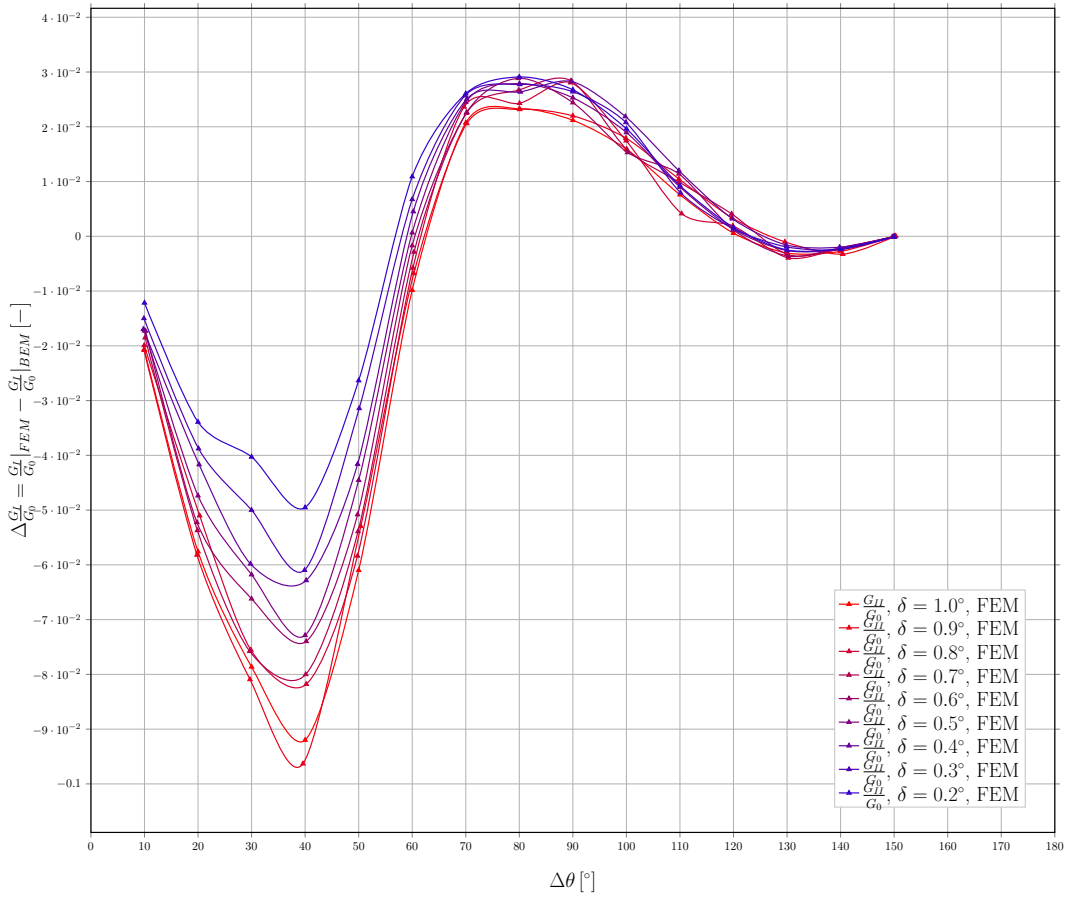
Error of of normalized energy release rate with respect to BEM results $\Delta\frac{G_I}{G_0} = \frac{G_I}{G_0}|_{FEM} - \frac{G_I}{G_0}|_{BEM}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VCCT post-p



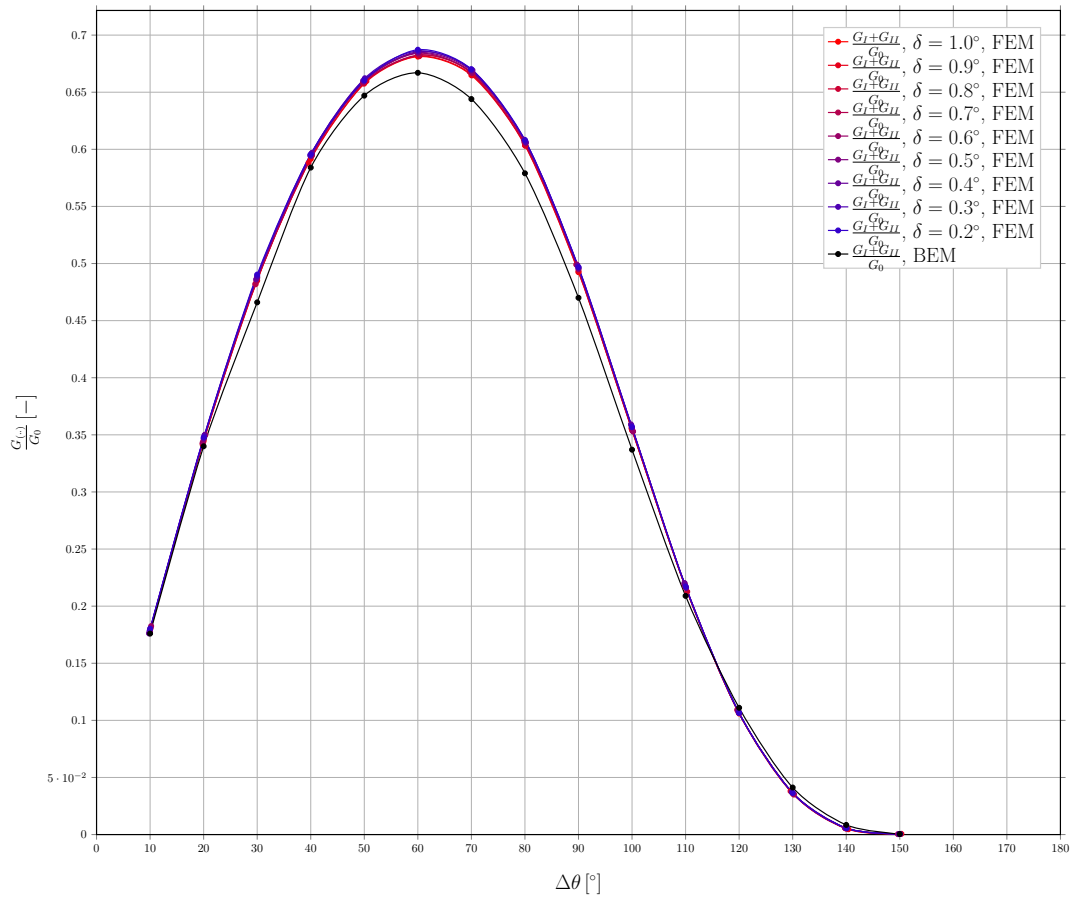
Normalized energy release rate $\frac{G_{II}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VCCT post-processing routine



Error of of normalized energy release rate with respect to BEM results $\Delta\frac{G_I}{G_0} = \frac{G_I}{G_0}|_{FEM} - \frac{G_I}{G_0}|_{BEM}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VCCT post-p



Normalized energy release rate $\frac{G_I+G_{II}}{G_0}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VCCT post-processing routine



Error of of normalized energy release rate with respect to BEM results $\Delta\frac{G_I+G_{II}}{G_0} = \frac{G_I+G_{II}}{G_0}|_{FEM} - \frac{G_I+G_{II}}{G_0}|_{BEM}$ as function of crack angular semi-aperture $\Delta\theta$, $VF_f = 7.9 \cdot 10^{-5}$, $\frac{L}{R_f} \sim 100$ calculated with in-house force-based VC