Euler in Use

ConTEXt support for the Euler math font, with examples

Abstract
The Euler math font was designed by Hermann Zapf. ConTEXt support was limited until now. We show how to use the Eulervm LaTEX package in combination with some new math definitions and typescripts to give a more informal look to your equations.

Keywords
ConTeXt, fonts, Euler, math

Introduction

The Euler math font was designed by Hermann Zapf. The underlying philosophy of Zapf's Euler design was to "capture the flavor of mathematics as it might be written by a mathematician with excellent handwriting." ConTEXt support had previously been limited, but now includes nearly all features available with ConTEXt's mathematics support. We show how to use the Eulervm LaTEX package in combination with some relatively new math definitions and typescripts to give a new look to your equations. Along the way, we provide several examples using ConTEXt's typescript and typeface mechanisms.

Although Euler has a somewhat informal feel that may make it inappropriate in certain situations, it does have certain advantages: as it does not directly mirror the form of any particular roman font (and has a robust weight), it mates with many more fonts than Computer Modern Math or others that are available. As D.E. Knuth himself had a hand in its creation, it offers features like optical scaling (e.g., script and scriptscript sizes) and multiple weights (i.e., bold math) not seen in most 'alternative' fonts. Most of the disadvantages that previously came with Euler use, chief among them poor glyph coverage, have disappeared with Walter Schmidt's Euler-VM package.

Typography can be very individual. I present the following possibilities as mere suggestions of how to get started. Please feel free to mix and match fonts and typescripts as you desire . . . I would hate for my peculiar tastes to be taken as some sort of dogma. My main motivation was to carry the freely available TEX fonts as far as possible.

Many thanks to Otared Kavian, who provided some of the source material that I liberally pilfered, and good beta-testing and initial feedback. Hans Hagen and Guy Worthington also provided advice, test material, and feedback at the early stages. Walter Schmidt provided the `Eulervm` package that I heavily rely upon.

Installation and basic usage

The Euler typescript requires the `Eulervm` virtual font package. For the `eulervm` file see http://www.ctan.org/tex-archive/help/Catalogue/entries/eulervm.html. Once you uncompress/unpack the file, examine the contents. It should contain, among others, two directories, `vf` and `tfm` the contents of the `vf` directory must be installed into the directory $TEXMFFONT/fonts/vf/public/eulervm, and the contents of the `tfm` directory must be installed into the directory $TEXMFFONT/fonts/tfm/public /eulervm. You are welcome to install the other, LaTeX–specific files if you like, but only the font files are of concern for use with ConTEXt. Don't forget to update your TEX hashes.

The other files that ConTEXt support relies upon are now integrated with the standard distribution. This includes several typescripts and a `math-eul` file that gives the location of specific math characters.

With the virtual fonts installed, you can test things with this simple document:

```
\definetypeface[eulermath][mm][math][euler][euler][rscale=1]
\setupbodyfont [eulermath]
\starttext
\showmathcharacters
\stoptext
```

This should yield the set of math characters shown at the end of the article in figure▶. Most distinctive to Euler are the greek and roman letters, while other characters are drawn from the default Computer Modern family.

Usage follows the general model shown above:

```
\definetypeface[name][mm][math][euler][euler][rscale=1]
```

The fourth argument ('euler') means to call the euler `name` and `encoding` typescripts, while the fifth argument ('euler') calls the Euler `size` (optical scaling) typescripts. The optional sixth argument allows a scaling to be applied to the Euler fonts relative to the main face. The whole cluster of font families grouped by `name` is then called with:

```
\setupbodyfont[name]
```

This will be illustrated throughout the rest of the article.

Examples of Euler in use

As Palatino was designed by Hermann Zapf, as Euler was, it forms the basis of the first suitable pairing in figure 1. We use Helvetica as the sans, not from any love, but because it is commonly and freely available.

```
\definetypeface[peul][rm][serif][palatino]  [default][encoding=texnansi]
\definetypeface[peul][ss][sans] [helvetica][default][encoding=texnansi,
                                                          rscale=.90]
\definetypeface[peul][tt][mono] [modern]    [default][encoding=texnansi,
                                                          rscale=1.1]
\definetypeface[peul][mm][math] [euler]     [euler]  [rscale=1.03]
```

1 Mixed faces on a page

In order to demonstrate the current typeface combination, we show the current faces *in situ* with an unusual, perhaps inordinate amount of ***style* switching**, as well as using macros that switch faces in order to demonstrate **key terms**, such as those that might be used in a textbook. Naturally, this somewhat affected approach will yield a fairly *extreme* page, but it can be worthwhile to look at a worst–case scenario, as well as a more moderate case, as with the other example.

Some of the most typographically offensive pages I have seen have been in international standards, with their `codeSnippets`, terminology, perhaps even mixed with a $\sqrt{x}$ radical function or two. Various typographers would certainly take issue with these practices, but on the other hand, certain conventions have been established.

2 MPEG-7 Audio

To extract the spectrum spread:

1. Calculate the power spectrum, $P'_x(n)$, and corresponding frequencies, $f(n)$, of the waveform as for `AudioSpectrumCentroid` extraction, parts a–b.

2. Calculate the spectrum centroid, C, as described in `AudioSpectrumCentroid` extraction in part d.

3. Calculate the spectrum spread, S, as the RMS deviation with respect to the centroid, on an octave scale:

$$S = \sqrt{\frac{\sum_n \left(\log_2(\frac{f(n)}{1000}) - C\right)^2 \cdot P'_x(n)}{\sum_n P'_x(n)}}$$

Figure 1. Palatino, Helvetica, CM-Typewriter, and Euler

The second pairing is the original usage of Euler: with DEK's Concrete font from *Concrete Mathematics* (shown in figure 2). We have to use a bit of a hack to get there, as the only freely available PostScript version[1] of the Concrete family is an adaptation of the font for Polish. As the encoding is a superset of the standard 7–bit TEX encoding, and already has ConTeXt support, it is easy to call this typescript as an extension of the pre–existing ConTEXt typescripts for Concrete. It could optionally be saved and called as a typescript on its own:

```
%\definetypescript[serif][concrete][pl0]
\loadmapfile      [pcr.map]
\definefontsynonym[ccr10]  [pcr10]  [encoding=pl0]
\definefontsynonym[ccti10] [pcti10] [encoding=pl0]
\definefontsynonym[ccsl10] [pcsl10] [encoding=pl0]
\definefontsynonym[cccsc10][pccsc10][encoding=pl0]
%\stoptypescript
```

Here are some of the simple operations we can do with the O-notation:

$$f(n) = O(f(n)), \tag{5}$$
$$c.O(f(n)) = O(f(n)), \qquad \text{if } c \text{ is a constant}, \tag{6}$$
$$O(f(n)) + O(f(n)) = O(f(n)), \tag{7}$$
$$O(O(f(n))) = O(f(n)), \tag{8}$$
$$O(f(n))O(g(n)) = O(f(n)g(n)), \tag{9}$$
$$O(f(n)g(n)) = f(n)O(g(n)). \tag{10}$$

The O-notation is also frequently used with functions of a complex variable z, in the neighborhood of $z = 0$. We write $O(f(z))$ to stand for any quantity $g(z)$ such that $|g(z)| \leqslant M|f(z)|$ whenever $|z| < r$. (As before, M and r are unspecified constants, although we could specify them if we wanted to.) The context of O-notation should always identify the variable that is involved and the range of that variable. When the variable is called n, we implicitly assume that $O(f(n))$ refers to functions of a large integer n; when the variable is called z, we implicitly assume that $O(f(z))$ refers to functions of a small complex number z.

Figure 2. Concrete and Euler

As the encoding is somewhat special, this combination may be of limited use with demanding or extensive accent requirements. Still, it is interesting and informative to see Euler with its first husband, so to speak:

```
\definetypeface[ceul][rm][serif][concrete][default][encoding=default]
\definetypeface[ceul][tt][mono] [modern]  [default][encoding=texnansi,
                                                    rscale=1.05]
\definetypeface[ceul][mm][math] [euler]   [euler]  [rscale=1]
```

The `default` encoding listed above is correct if used with the bare synonyms shown above. If enclosed in a typescript, it is most correct to call (and label) that typescript with the `pl0` encoding.

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Figure 3. Antykwa Toruńska and Euler

I have a certain fondness for the somewhat alien (to western eyes), but utterly charming Antykwa Toruńska family[2], which in recent months has got an update to be one of the most complete font families freely available in TEX land (it is illustrated in figure 3). I discuss in another article methods of unlocking the features in this family, but for now we examine the basic pairing of Antykwa Toruńska with Euler, which seem to hold echoes of each others' letterforms:

```
\loadmapfile[texnansi-antt.map]
\definetypeface[aeul][rm][serif][antykwa-torunska][default]
                                                      [encoding=texnansi]
\definetypeface[aeul][tt][mono] [modern]           [default]
                                                      [encoding=texnansi,
                                                             rscale=1.05]
\definetypeface[aeul][mm][math] [euler]            [euler]   [rscale=1]
```

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$$S = \sqrt{\frac{\sum_n \left(\log_2(\frac{f(n)}{1000}) - C\right)^2 \cdot P'_x(n)}{\sum_n P'_x(n)}}$$

Figure 4. Bitstream Charter, Bera Sans and Mono, and Euler

Finally, we examine a popular combination between Bitstream Charter and Euler. The editors of MAPS seem to like it, and I found it useful as well in my first major ConTEXt excursion. In this variation, I marry Bera[3] (the TEXified version of the Open Source Bitstream Vera) with the others as the mono and sans font families (shown in figure 4). I'm not entirely convinced of the pairing (inspired by a more successful local experiment with Adobe Myriad), but I hope others find it instructive.

```
\definetypeface[cheu][rm][serif] [charter][default][encoding=texnansi]
\definetypeface[cheu][ss][sans]  [bera]   [default][encoding=texnansi,
                                                     rscale=.89]
\definetypeface[cheu][tt][mono]  [bera]   [default][encoding=texnansi,
                                                     rscale=.89]
\definetypeface[cheu][mm][math]  [euler]  [euler]  [rscale=1.05]
```

Mixed bold math is also available with Euler. General usage is as described in the ConTEXt magazine 'This Way #5'[4], and you simply need to add this to the above typescript to enable mixed math:

```
\definetypeface[cheu][mm][bfmath][euler]  [euler]  [rscale=1.05]
\setupformulas [method=bold]
```

Footnotes

1. Available from http://www.ctan.org/tex-archive/fonts/psfonts/polish/cc-pl/
2. Antykwa Toruńska's TEX package can be downloaded from http://www.janusz.nowacki.strefa.pl/torunska-e.html. Only the font directory needs to be installed for ConTEXt purposes.
3. TeXfont should be used to install Bera: http://www.ctan.org/tex-archive/fonts/bera/.
4. Download from http://pragma-ade.com/general/magazines/mag-0005.pdf

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math characters – eul

α	0	alpha	K	0	Kappa	$\spadesuit$	2	spadesuit	$\mp$	2	mp
β	0	beta	Λ	0	Lambda	$\coprod$	3	coprod	$\pm$	2	pm
γ	0	gamma	M	0	Mu	$\bigvee$	3	bigvee	$\circ$	2	circ
δ	0	delta	N	0	Nu	$\bigwedge$	3	bigwedge	$\bigcirc$	2	bigcirc
ϵ	0	epsilon	Ξ	0	Xi	$\biguplus$	3	biguplus	$\setminus$	2	setminus
ζ	0	zeta	O	0	Omicron	$\bigcap$	3	bigcap	$\cdot$	2	cdot
η	0	eta	Π	0	Pi	$\bigcup$	3	bigcup	$\ast$	2	ast
θ	0	theta	R	0	Rho	$\int$	3	intop	$\times$	2	times
ι	0	iota	Σ	0	Sigma	$\prod$	3	prod	$\star$	1	star
κ	0	kappa	T	0	Tau	$\sum$	3	sum	$\propto$	2	propto
λ	0	lambda	Υ	0	Upsilon	$\bigotimes$	3	bigotimes	$\sqsubseteq$	2	sqsubseteq
μ	0	mu	Φ	0	Phi	$\bigoplus$	3	bigoplus	$\sqsupseteq$	2	sqsupseteq
ν	0	nu	X	0	Chi	$\bigodot$	3	bigodot	$\parallel$	2	parallel
ξ	0	xi	Ψ	0	Psi	$\oint$	3	ointop	$\mid$	2	mid
o	0	omicron	Ω	0	Omega	$\bigsqcup$	3	bigsqcup	$\dashv$	2	dashv
π	0	pi	$\aleph$	2	aleph	$\smallint$	2	smallint	$\vdash$	2	vdash
ρ	0	rho	$\imath$	1	imath	$\triangleleft$	1	triangleleft	$\nearrow$	2	nearrow
σ	0	sigma	$\jmath$	1	jmath	$\triangleright$	1	triangleright	$\searrow$	2	searrow
τ	0	tau	ℓ	1	ell	$\bigtriangleup$	2	bigtriangleup	$\nwarrow$	2	nwarrow
υ	0	upsilon	$\wp$	1	wp	$\bigtriangledown$	2	bigtriangledown	$\swarrow$	2	swarrow
ϕ	0	phi	$\Re$	2	Re	$\wedge$	2	wedge	$\Leftrightarrow$	2	Leftrightarrow
χ	0	chi	$\Im$	2	Im	$\vee$	2	vee	$\Leftarrow$	2	Leftarrow
ψ	0	psi	∂	1	partial	$\cap$	2	cap	$\Rightarrow$	2	Rightarrow
ω	0	omega	∞	2	infty	$\cup$	2	cup	$\leq$	2	leq
ε	0	varepsilon	$\prime$	2	prime	$\ddagger$	2	ddagger	$\geq$	2	geq
ϑ	0	vartheta	$\emptyset$	2	emptyset	$\dagger$	2	dagger	$\succ$	2	succ
ϖ	0	varpi	∇	2	nabla	$\sqcap$	2	sqcap	$\prec$	2	prec
ϱ	0	varrho	$\top$	2	top	$\sqcup$	2	sqcup	$\approx$	2	approx
ς	0	varsigma	$\bot$	2	bot	$\uplus$	2	uplus	$\succeq$	2	succeq
φ	0	varphi	$\triangle$	2	triangle	$\amalg$	2	amalg	$\preceq$	2	preceq
A	0	Alpha	$\forall$	2	forall	$\diamond$	2	diamond	$\supset$	2	supset
B	0	Beta	$\exists$	2	exists	$\bullet$	2	bullet	$\subset$	2	subset
Γ	0	Gamma	$\neg$	2	neg	$\wr$	2	wr	$\supseteq$	2	supseteq
Δ	0	Delta	$\flat$	1	flat	$\div$	2	div	$\subseteq$	2	subseteq
E	0	Epsilon	$\natural$	1	natural	$\odot$	2	odot	$\in$	2	in
Z	0	Zeta	$\sharp$	1	sharp	$\oslash$	2	oslash	$\ni$	2	ni
H	0	Eta	$\clubsuit$	2	clubsuit	$\otimes$	2	otimes	$\gg$	2	gg
Θ	0	Theta	$\diamondsuit$	2	diamondsuit	$\ominus$	2	ominus	$\ll$	2	ll
I	0	Iota	$\heartsuit$	2	heartsuit	$\oplus$	2	oplus	$/$	2	not

Figure 5. Euler character list

↔	2	leftrightarrow	∣	2	vert	⊠	C	boxtimes	≳	C	gtrsim
←	2	leftarrow	↑	2	uparrow	□	C	square	⪆	C	gtrapprox
→	2	rightarrow	↓	2	downarrow	□	C	Box	⊸	C	multimap
╵	2	mapstochar	↕	2	updownarrow	■	C	blacksquare	∴	C	therefore
∼	2	sim	⇑	2	Uparrow	▪	C	centerdot	∵	C	because
≃	2	simeq	⇓	2	Downarrow	◊	C	Diamond	≑	C	doteqdot
⊥	2	perp	⇕	2	Updownarrow	◊	C	lozenge	≑	C	Doteq
≡	2	equiv	\	2	backslash	⧫	C	blacklozenge	≜	C	triangleq
≍	2	asymp	⟩	2	rangle	↻	C	circlearrowright	≾	C	precsim
⌣	1	smile	⟨	2	langle	↺	C	circlearrowleft	≲	C	lesssim
⌢	1	frown	}	2	rbrace	⇌	C	rightleftharpoons	⪅	C	lessapprox
↼	1	leftharpoonup	{	2	lbrace	⇋	C	leftrightharpoons	⪕	C	eqslantless
↽	1	leftharpoondown	⌉	2	rceil	⊟	C	boxminus	⪖	C	eqslantgtr
⇀	1	rightharpoonup	⌈	2	lceil	⊩	C	Vdash	⋞	C	curlyeqprec
⇁	1	rightharpoondown	⌋	2	rfloor	⊪	C	Vvdash	⋟	C	curlyeqsucc
‘	1	lhook	⌊	2	lfloor	⊨	C	vDash	≼	C	preccurlyeq
’	1	rhook	√	2	sqrt	↠	C	twoheadrightarrow	≦	C	leqq
.	1	ldotp	†	2	dag	↞	C	twoheadleftarrow	⩽	C	leqslant
·	2	cdotp	‡	2	ddag	⇇	C	leftleftarrows	≶	C	lessgtr
:	0	colon	§	2	S	⇉	C	rightrightarrows	‵	C	backprime
	0	acute	¶	2	P	⇈	C	upuparrows	-	C	dabar@
	0	grave	◯	2	Orb	⇊	C	downdownarrows	≓	C	risingdotseq
	0	ddot	.	1	mathperiod	↾	C	upharpoonright	≒	C	fallingdotseq
	0	tilde	.	1	textperiod	↾	C	restriction	≽	C	succcurlyeq
	0	bar	,	1	mathcomma	⇂	C	downharpoonright	≧	C	geqq
	0	breve	,	1	textcomma	↿	C	upharpoonleft	⩾	C	geqslant
	0	check	Γ	0	varGamma	⇃	C	downharpoonleft	≷	C	gtrless
^	0	hat	Δ	0	varDelta	↣	C	rightarrowtail	⊏	C	sqsubset
→	1	vec	Θ	0	varTheta	↢	C	leftarrowtail	⊐	C	sqsupset
	0	dot	Λ	0	varLambda	⇆	C	leftrightarrows	▷	C	vartriangleright
~	3	widetilde	Ξ	0	varXi	⇄	C	rightleftarrows	▷	C	rhd
^	3	widehat	Π	0	varPi	↰	C	Lsh	◁	C	lhd
⎰	3	lmoustache	Σ	0	varSigma	↱	C	Rsh	◁	C	vartriangleleft
⎱	3	rmoustache	ϒ	0	varUpsilon	⇝	C	rightsquigarrow	⊵	C	trianglerighteq
(	0	lgroup	Φ	0	varPhi	⇝	C	leadsto	⊵	C	unrhd
)	0	rgroup	Ψ	0	varPsi	↭	C	leftrightsquigarrow	⊴	C	trianglelefteq
∣	2	arrowvert	Ω	0	varOmega	↫	C	looparrowleft	⊴	C	unlhd
‖	2	Arrowvert	↘	2	internalAnd	↬	C	looparrowright	★	C	bigstar
╻	3	bracevert	⊡	C	boxdot	≗	C	circeq	≬	C	between
‖	2	Vert	⊞	C	boxplus	≿	C	succsim	▼	C	blacktriangledow

Figure 5. Euler character list – continued

$\blacktriangleright$	C blacktriangleright	$\lll$	C lll	$\nleqq$	D nleqq	$\nrightarrow$	D nrightarrow
$\blacktriangleleft$	C blacktriangleleft	$\gggtr$	C gggtr	$\ngeqq$	D ngeqq	$\nLeftarrow$	D nLeftarrow
$\vartriangle$	C vartriangle	$\ggg$	C ggg	$\precneqq$	D precneqq	$\nRightarrow$	D nRightarrow
$\triangleup$	C triangleup	$\ulcorner$	C ulcorner	$\succneqq$	D succneqq	$\nLeftrightarrow$	D nLeftrightarrow
$\blacktriangle$	C blacktriangle	$\urcorner$	C urcorner	$\precnapprox$	D precnapprox	$\nleftrightarrow$	D nleftrightarrow
$\triangledown$	C triangledown	$\circledS$	C circledS	$\succnapprox$	D succnapprox	$\divideontimes$	D divideontimes
$\eqcirc$	C eqcirc	$\pitchfork$	C pitchfork	$\lnapprox$	D lnapprox	$\varnothing$	D varnothing
$\lesseqgtr$	C lesseqgtr	$\dotplus$	C dotplus	$\gnapprox$	D gnapprox	$\nexists$	D nexists
$\gtreqless$	C gtreqless	$\backsim$	C backsim	$\nsim$	D nsim	$\Finv$	D Finv
$\lesseqqgtr$	C lesseqqgtr	$\backsimeq$	C backsimeq	$\ncong$	D ncong	$\Game$	D Game
$\gtreqqless$	C gtreqqless	$\llcorner$	C llcorner	$\diagup$	D diagup	$\mho$	D mho
$\Rrightarrow$	C Rrightarrow	$\lrcorner$	C lrcorner	$\diagdown$	D diagdown	$\eth$	D eth
$\Lleftarrow$	C Lleftarrow	$\complement$	C complement	$\varsubsetneq$	D varsubsetneq	$\eqsim$	D eqsim
$\veebar$	C veebar	$\intercal$	C intercal	$\varsupsetneq$	D varsupsetneq	$\beth$	D beth
$\barwedge$	C barwedge	$\circledcirc$	C circledcirc	$\nsubseteqq$	D nsubseteqq	$\gimel$	D gimel
$\doublebarwedge$	C doublebarwedge	$\circledast$	C circledast	$\nsupseteqq$	D nsupseteqq	$\daleth$	D daleth
$\angle$	C angle	$\circleddash$	C circleddash	$\subsetneqq$	D subsetneqq	$\lessdot$	D lessdot
$\measuredangle$	C measuredangle	$\lvertneqq$	D lvertneqq	$\supsetneqq$	D supsetneqq	$\gtrdot$	D gtrdot
$\sphericalangle$	C sphericalangle	$\gvertneqq$	D gvertneqq	$\varsubsetneqq$	D varsubsetneqq	$\ltimes$	D ltimes
$\varpropto$	C varpropto	$\nleq$	D nleq	$\varsupsetneqq$	D varsupsetneqq	$\rtimes$	D rtimes
$\smallsmile$	C smallsmile	$\ngeq$	D ngeq	$\subsetneq$	D subsetneq	$\shortmid$	D shortmid
$\smallfrown$	C smallfrown	$\nless$	D nless	$\supsetneq$	D supsetneq	$\shortparallel$	D shortparallel
$\Subset$	C Subset	$\ngtr$	D ngtr	$\nsubseteq$	D nsubseteq	$\smallsetminus$	D smallsetminus
$\Supset$	C Supset	$\nprec$	D nprec	$\nsupseteq$	D nsupseteq	$\thicksim$	D thicksim
$\Cup$	C Cup	$\nsucc$	D nsucc	$\nparallel$	D nparallel	$\thickapprox$	D thickapprox
$\doublecup$	C doublecup	$\lneqq$	D lneqq	$\nmid$	D nmid	$\approxeq$	D approxeq
$\Cap$	C Cap	$\gneqq$	D gneqq	$\nshortmid$	D nshortmid	$\succapprox$	D succapprox
$\doublecap$	C doublecap	$\nleqslant$	D nleqslant	$\nshortparallel$	D nshortparallel	$\precapprox$	D precapprox
$\curlywedge$	C curlywedge	$\ngeqslant$	D ngeqslant	$\nvdash$	D nvdash	$\curvearrowleft$	D curvearrowleft
$\curlyvee$	C curlyvee	$\lneq$	D lneq	$\nVdash$	D nVdash	$\curvearrowright$	D curvearrowright
$\leftthreetimes$	C leftthreetimes	$\gneq$	D gneq	$\nvDash$	D nvDash	$\digamma$	D digamma
$\rightthreetimes$	C rightthreetimes	$\npreceq$	D npreceq	$\nVDash$	D nVDash	$\varkappa$	D varkappa
$\subseteqq$	C subseteqq	$\nsucceq$	D nsucceq	$\ntrianglerighteq$	D ntrianglerighteq	$\Bbbk$	D Bbbk
$\supseteqq$	C supseteqq	$\precnsim$	D precnsim	$\ntrianglelefteq$	D ntrianglelefteq	$\hslash$	D hslash
$\bumpeq$	C bumpeq	$\succnsim$	D succnsim	$\ntriangleleft$	D ntriangleleft	$\hbar$	D hbar
$\Bumpeq$	C Bumpeq	$\lnsim$	D lnsim	$\ntriangleright$	D ntriangleright	$\backepsilon$	D backepsilon
$\llless$	C llless	$\gnsim$	D gnsim	$\nleftarrow$	D nleftarrow		

Figure 5. Euler character list – continued