OpenType Math Fonts: What's new or noteworthy?

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10+ years of OpenType math fonts

- Some milestones
  - 2007: engine support in MS Office; Cambria Math
  - 2008: engine support in XeTeX, XeLaTeX; Asana Math
  - 2009: engine support in LuaTeX, LuaLaTeX, ConTeXt
  - 2010: engines + macros + fonts in TeX Live; XITS Math
  - 2011: Latin Modern Math (GUST Team)
  - 2011–12: Lucida Math (TUG, Bigelow & Holmes)
  - 2012–16: TeX Gyre Math (4x) + DejaVu (GUST Team)
  - 2013–16: STIX Math, STIX Two Math
  - 2016–19: Libertinus Math, Garamond Math, Fira Math, etc.

10+ years of OpenType math fonts

- engine support: mostly stable
  - TEX engines: LuaTEX 1.0x, XeTEX 0.99999x
  - MS engines: Office 2007, 2010, etc
  - Browser support: Mozilla Firefox + Plugins
- macro support: mostly stable
  - LuaLaTEX/XeLaTEX (via `unicode-math`)
  - ConTEXt Mk IV
  - Plain LuaTEX (via `luatex-plain`)
- font development: ongoing
  - some 15–18 math fonts available
  - some fonts still under development
  - (+ some bold variants)
  - (+ some sans-serif designs)
  - (+ some extra weights)

Choices of OpenType math fonts

- by origin
  - traditional TEX fonts: Latin Modern (+ Euler + AMS Symbols)
  - traditional PS Fonts: TEX Gyre, XITS/STIX/STIX2
  - other: Cambria, Lucida, Minion, Libertinus, DejaVu
- by developer
  - GUST Team: Latin Modern, TEX Gyre, DejaVu
  - Khaled Hosny: XITS, Lucida, Libertinus
  - other: STIX/STIX2, Cambria, Asana, Minion
  - recent additions: Garamond, Fira, GFS, etc
- by availability
  - from CTAN: Latin Modern, TEX Gyre, XITS/STIX/STIX2
  - from CTAN or `github`: Libertinus, Garamond, Fira, GFS
  - sold commercially: Lucida (via TUG), Minion
  - as system fonts: Cambria (on Windows 7 or 10)

Choices of OpenType math fonts

- by release date
  - Cambria Math, since 2007
  - Asana Math, since 2008
  - Neo Euler, since 2009 (abandoned)
  - XITS Math, since 2010 (from STIX 1.0)
  - STIX Math, June 2013 (from STIX 1.1)
  - Latin Modern Math, May 2011
  - Minion Math, Oct 2011
  - Lucida Math, March 2012
  - TEX Gyre Pagella Math, May 2012
  - TEX Gyre Termes Math, Sept 2012
  - TEX Gyre Bonum Math, May 2013
  - TEX Gyre Schola Math, May 2014
  - (TEX Gyre) DejaVu Math, May 2015/16

Choices of OpenType math fonts

- by release date (recent additions)
  - STIX Two Math, Dec 2016 (latest in Apr 2019)
  - Libertinus Math, since 2016 (latest in Apr 2019)
  - Garamond Math, since 2018 (latest in Feb 2019)
  - Fira Math, since 2018 (latest in Feb 2019)
  - GFS Neohellenic Math, since ???
- Choices of sans-serif math
  - Fira Math
  - GFS Neohellenic Math
- Choices of bold math
  - XITS Math Bold
  - Lucida Math Demi
  - Libertinus Math Bold
- Multiple weights / sizes
  - Fira Math (12 weights)
  - Minion (4 weights, 5 sizes)

Recent OpenType math fonts

- Libertinus Math
  - alphabets from Libertine, sans-serif from Biolinum
  - Scripts from XITS Math, BBold constructed, no Fraktur

$$\Delta \boldsymbol{E} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{E}}{\partial t^2} = \frac{1}{\varepsilon_0}\nabla\lambda + \mu_0\frac{\partial \boldsymbol{j}}{\partial t}\,, \qquad \Delta \boldsymbol{B} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{B}}{\partial t^2} = -\mu_0 \operatorname{rot} \boldsymbol{j}$$

$$\mathrm{i}\hbar\frac{\partial \psi}{\partial t} = \frac{1}{2m}\left(\frac{\hbar}{\mathrm{i}}\nabla - q\boldsymbol{A}(\boldsymbol{r})\right)^2\psi + q\phi(\boldsymbol{r})\,\psi$$

$$\gamma^\alpha\left(\frac{\hbar}{\mathrm{i}}\partial_\alpha - qA_\alpha\right)\psi + m_0 c\,\psi = 0$$

$$R^{\mu\nu} - \frac{1}{2}Rg^{\mu\nu} + \Lambda g^{\mu\nu} = -\frac{8\pi G}{c^2}M^{\mu\nu}$$

Recent OpenType math fonts

- Garamond Math
  - alphabets from EB Garamond, sans-serif from Libertinus
  - Scripts from XITS Math, BBold constructed, no Fraktur

$$\Delta \boldsymbol{E} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{E}}{\partial t^2} = \frac{1}{\varepsilon_0}\nabla\lambda + \mu_0\frac{\partial \boldsymbol{j}}{\partial t}, \quad \Delta \boldsymbol{B} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{B}}{\partial t^2} = -\mu_0 \operatorname{rot} \boldsymbol{j}$$

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$$R^{\mu\nu} - \frac{1}{2}Rg^{\mu\nu} + \Lambda g^{\mu\nu} = -\frac{8\pi G}{c^2}M^{\mu\nu}$$

Recent OpenType math fonts

- Fira Math
  - sans-serif design, no alternate sans-serif
  - no Script, Fraktur, full BBold

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Recent OpenType math fonts

- GFS Neohellenic Math
  - sans-serif design, no alternate sans-serif
  - minimal Scripts, Fraktur, BBold

$$\Delta \boldsymbol{E} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{E}}{\partial t^2} = \frac{1}{\varepsilon_0}\boldsymbol{\nabla}\lambda + \mu_0 \frac{\partial \boldsymbol{j}}{\partial t}, \quad \Delta \boldsymbol{B} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{B}}{\partial t^2} = -\mu_0 \operatorname{rot} \boldsymbol{j}$$

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$$R^{\mu\nu} - \frac{1}{2}Rg^{\mu\nu} + \Lambda g^{\mu\nu} = -\frac{8\pi G}{c^2}M^{\mu\nu}$$

Status of OpenType math font development

- Completeness
  - Completeness of math symbols
  - Completeness of math alphabets
- Design issues
  - How to choose matching fonts?
  - How should certain fonts look like?
- Technical issues
  - Spacing and side bearings
  - Placements of accents
  - Placements of superscripts / subscripts

Completeness of math symbols

- Unicode math defines hundreds of math symbols (1200+)
- OpenType math fonts can choose what to implements
  - most fonts have some missing symbols
  - each font can have different range
  - Latin Modern and TEX Gyre cover the same subsets
  - all fonts have common subset (traditional TEX)
- How complete are math symbols?
  - most complete: XITS/STIX/STIX2
  - mostly complete: Minion, GFS, Asana, Cambria, Lucida
  - in between: Latin Modern, TEX Gyre, Garamond
  - less complete: Libertinus, Fira, (Neo Euler)

Completeness of math alphabets

- Unicode math defines dozens of math alphabets
- OpenType math fonts can choose what to implement
  - most fonts have some missing symbols/alphabets
  - e.g. bold sans-serif Greek (upright + italic)
  - e.g. lowercase Script, bold Script, bold Fraktur
  - e.g. lowercase BBold, numerals BBold
- How complete are math alphabets?
  - most complete: XITS/STIX/STIX2
  - also complete: Asana, Cambria, TEX Gyre
  - in between: Latin Modern, Lucida, Libertinus, Garamond
  - less complete: Minion, GFS, Fira, (Neo Euler)

Completeness of math alphabets

- What is missing in various fonts?
  - Latin Modern: lower Script (regular + bold)
  - Lucida: lower bold Script, lower bold Fraktur
  - Libertinus: bold sans italic Greek, all Fraktur
  - Garamond: bold sans italic Greek, all Fraktur
  - Minion: all Script, all Fraktur, lower BBold
  - GFS: lower+bold Script, Fraktur, lower BBold
  - Fira: all Script, all Fraktur
- In some cases, there are special reasons:
  - sans-serif designs: empty slots for sans-serif
  - multiple weights: emtpy slots for bold

Completeness of symbols and alphabets

- How complete are various fonts?

STIX Math	1225 symbols +	1168 alphabetic
XITS Math	1253 symbols +	1170 alphabetic
STIX Two Math	1256 symbols +	1170 alphabetic
Minion Math	1215 symbols +	280 alphabetic
GFS Neohellenic	1174 symbols +	568 alphabetic
Asana Math	1172 symbols +	1167 alphabetic
Cambria Math	1158 symbols +	1170 alphabetic
Lucida Math	944 symbols +	1038 alphabetic
TEX Gyre Math (5x)	556 symbols +	1163 alphabetic
Latin Modern Math	554 symbols +	1111 alphabetic
Garamond Math	558 symbols +	989 alphabetic
Libertinus Math	535 symbols +	992 alphabetic
Fira Math	445 symbols +	584 alphabetic
Neo Euler	251 symbols +	399 alphabetic

Completeness of symbols and alphabets

- Bold Math

XITS Math	1253 symbols +	1170 alphabetic
XITS Math Bold	499 symbols +	1093 alphabetic
Lucida Math	944 symbols +	1038 alphabetic
Lucida Math Demi	472 symbols +	961 alphabetic
Libertinus Math	535 symbols +	992 alphabetic
Libertinus Math Bold	535 symbols +	992 alphabetic

- Sans-serif Math

GFS Neohellenic	1174 symbols +	568 alphabetic
Fira Math	445 symbols +	584 alphabetic

Design issues: Choices of matching fonts

- Unicode math combines multiple alphabets
  (e.g. Serif, Sans Serif, Script, Fraktur, BBold)
- OpenType math fonts need to choose matching fonts
  - no problem for comprehensive families (LM, Lucida)
  - non-trivial design issue for most other font families
- Choosing a matching sans-serif font
  - Which sans-serif fonts are available and complete enough?
  - Sans-serif should be clearly distinguishable from Serif
  - Sans-serif should not be too incompatible with Serif
  - Sans-serif should match the weight, width, angle, shapes
- Choosing a matching Script or Fraktur font
  - Which Script or Fraktur fonts are available?
  - Script and Fraktur should match expected style

Technical issues

- OpenType math fonts need extensive testing
  - testing and fine-tuning the spacing (side-bearings)
  - testing the placement of accents, superscripts, subscripts
  - checking visual consistency of alphabets and symbols
  - It is easy to tell, if something looks wrong
  - It is not easy to tell how it should be right
- font support varies a lot
  - some font projects have frequent releases
  - some font projects take years to next release
  - some system fonts are updated without notice
  - some bugs get fixed eventually, but may take years

Summary and Conclusions

- Where are we?
  - OpenType math font technology established for 10+ years
  - OpenType math fonts provide advantages to users
  - OpenType math fonts pose challenges to developers
- How are we doing?
  - Several recent additions and new releases of fonts
  - Choices of math fonts have grown to 15–18 fonts
  - Coverage of symbols and alphabets has also improved
  - some fonts may need another round of revisions
- Is OpenType math ready for use?
  - Completeness depends on what you are using
  - Stability depends on how you are using it