Visualisation and Animations in Mathematics Education and Electronic Teaching Material

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1. Introduction

We are currently developing electronic teaching material for differential geometry at the Department of Mathematics of the University of Niš. [1] It consists of

1. an electronic textbook

   written in **LaTeX**

   available in **PDF format**

2. graphics and animations developed with our **own graphics software**

3. interactive elements by means of our **interface** for our software

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2. LaTeX

LaTeX is most suitable for typing mathematical test; it renders the best display of mathematical formulae. The **PDF** format is directly created from the **LaTeX** source code by **PDFLATEX**.
(cf. [3, 4, 4, 5, 6, 2]; [1] for *HTML*)

Example **2.1** *Some typical mathematical text typed in*

LaTeX *and converted to PDF.*

As a comparison we show the result after the conversion into an

HTML *file with* **LATEX2HTHL**

We also look a the

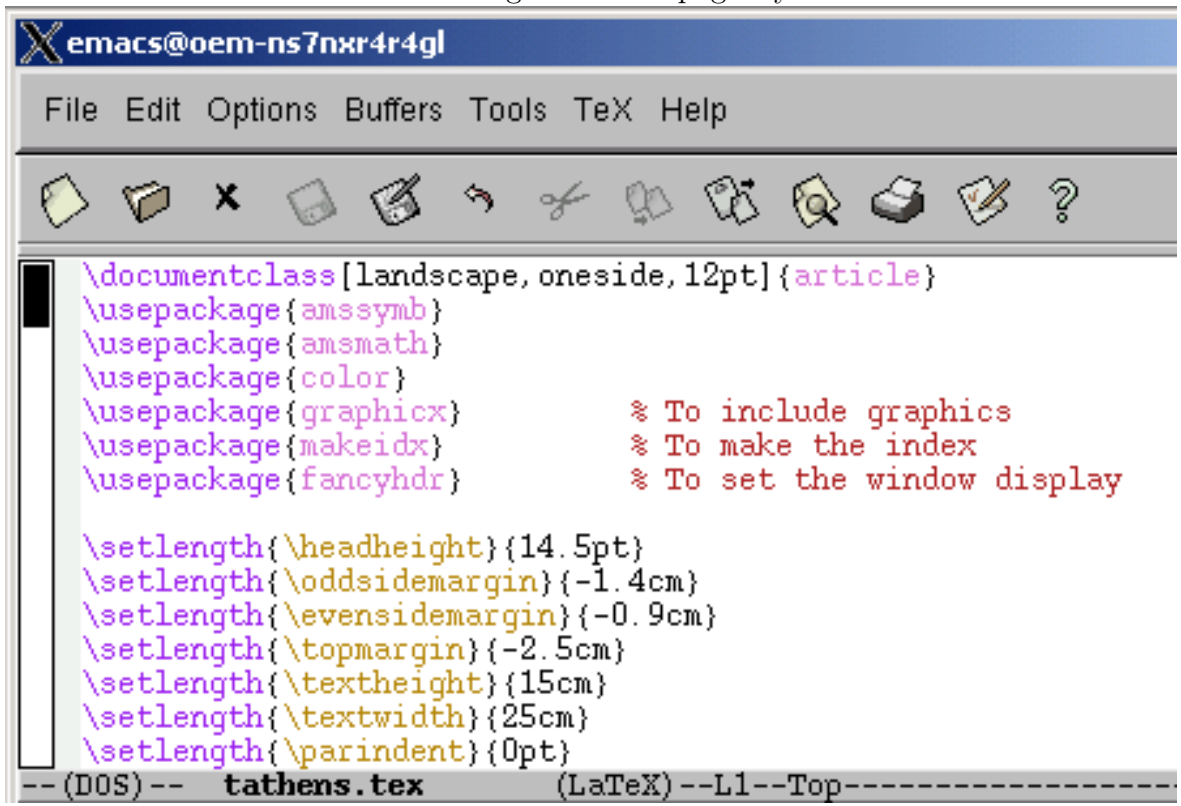
Latex Source Code

An alternative might be the use of **MATHML**.

2.1. The Template

The page layout is chosen to fit optimally into the window of the viewer.

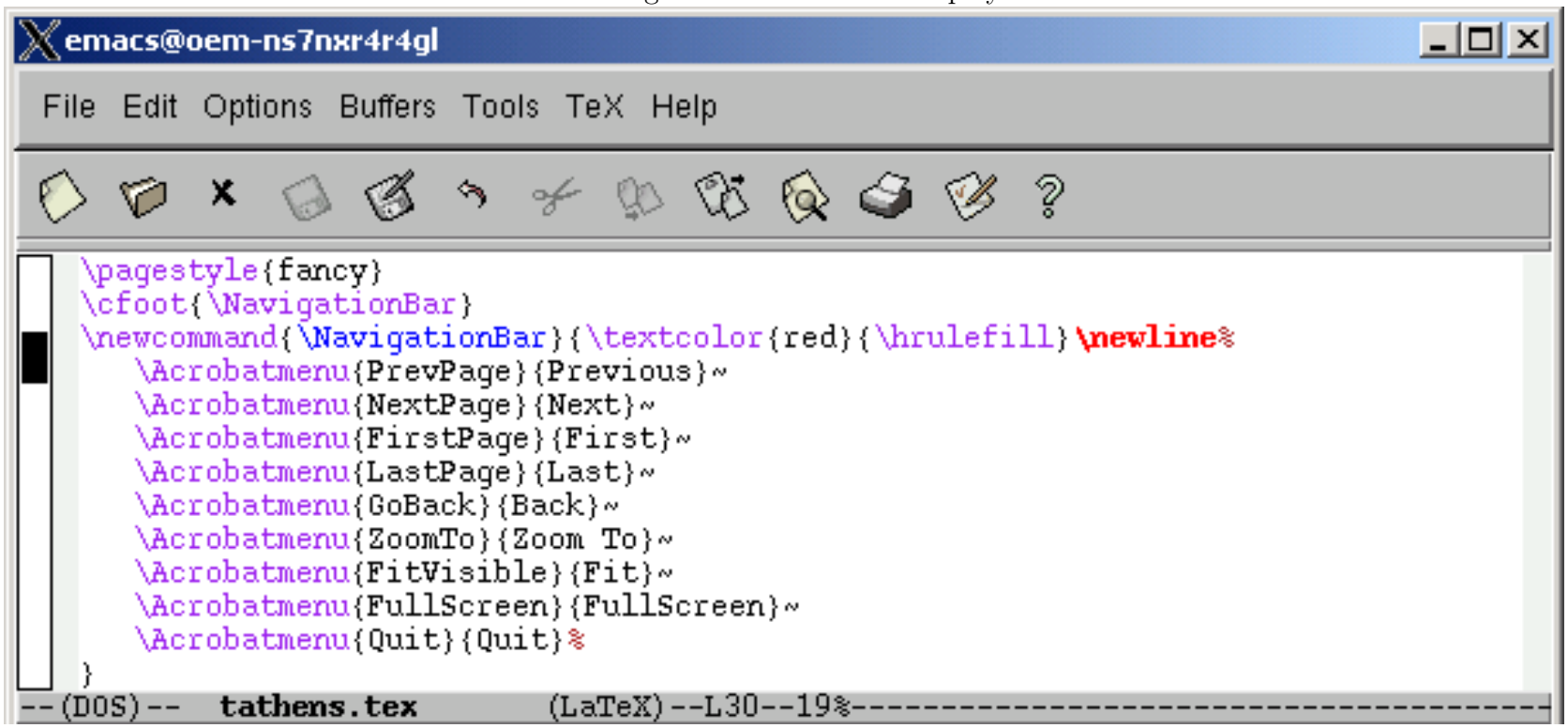
Figure 1: The page layout



2.2. The Window Display

We define our own window display as shown in Figure 2 and obtain the navigation bar at the bottom of the page.

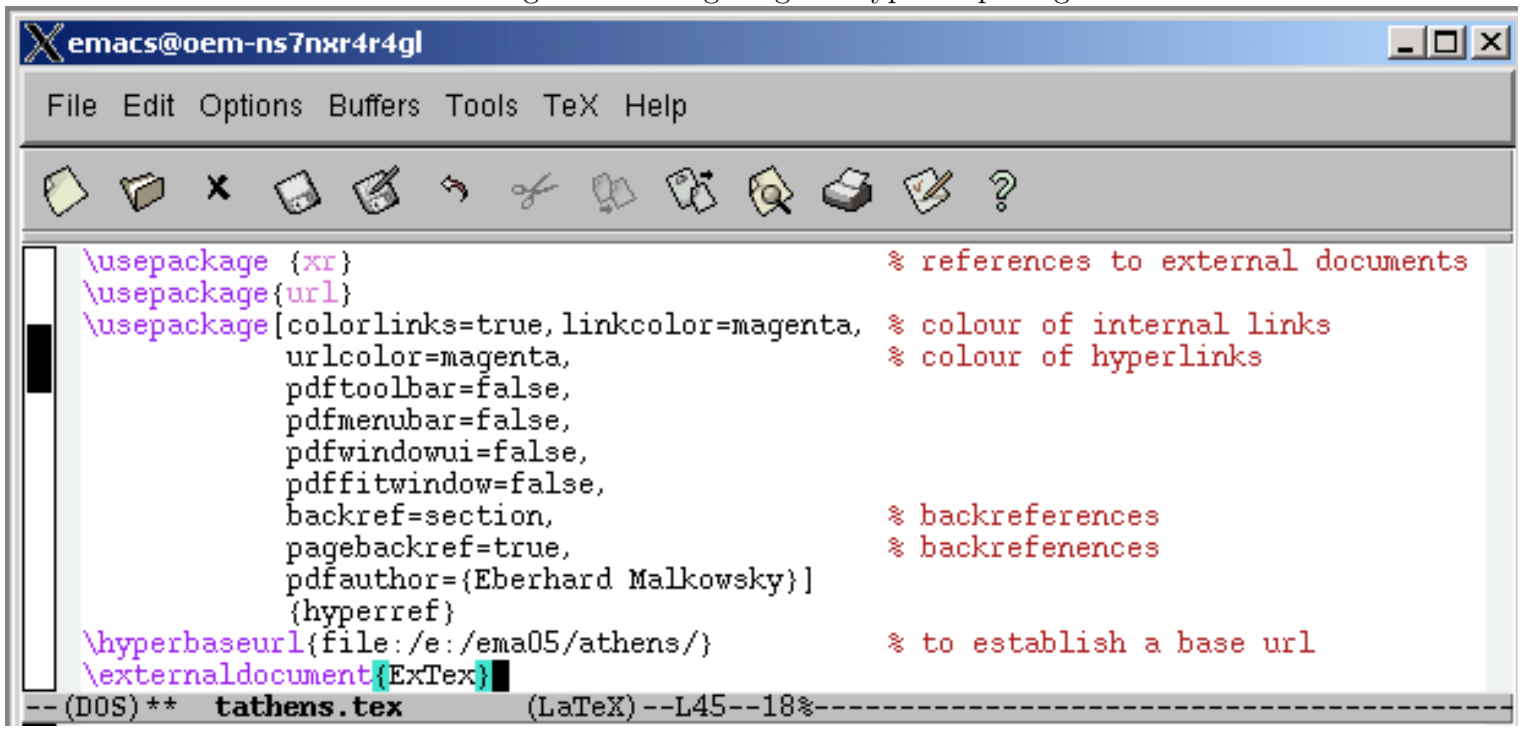
Figure 2: The window display



2.3 The Links

The **hyperref package** provides **Macros** to write links, including those to **external documents** and **URLs** (cf. [4, 2]).

Figure 3: Configuring the hyperref package



Warning: *The hyperref package should be the* **LAST** *of the packages* to make sure the links work properly.
The most important macros are

1. `\href{`*url*`}{`*text*`}`
   The *text* is made to a hyperlink to the *url*
2. `\hyperrdef{`*category*`}{`*name*`}{`*text*`}`
   A target area of a document (the *text*) is marked and given the name *category.name*
3. `\hyperref{`*url*`}{`*category*`}{`*name*`}{text}`
   The text is made into a link to *url#category.name*.

The option `backref` inserts extra backlinks in the bibliography for each entry. In our preamble we have chosen *pagebackref=true*, so the number of the page where the citation was made is given.

Example **2.2** *(1.) We link to the file GStar31.hm with relative Url animat by means of the command*

```
\href{animat/G3Star32.htm}{Neighbourhoods}
```

to achieve Neighbourhoods
(2.) We link to the figure in the file ExTex.pdf. The target is marked by `\hyperdef{Figure}{ExTexFigure1}{}`*. We use the command*

```
\hyperref{ExTex.pdf}{Figure}{ExTexFigure1}{isothermal
parameters}
```

to achieve isothermal parameters.
(3.) We refer to Proposition 1.2 in the file ExTex.pdf; it has the label ExTex.S.1.Prop1 in the file ExTex.tex. We use the command

```
\ref{ExTex.S.1.Prop1}
```

to obtain the correct number 1.2 of the Proposition, as in: We know from Proposition 1.2 in our paper entitled .... that isothermal parameters exist for any surface of rotation.

More details can be found in [4, Chapter 2.3].

Remark 2.3 *Hyperlinks to bookmarks in external* **PDF** *files only work properly when the* **ACROBAT Reader** *is set to*

Open Cross-Doc Links in Same Window
in File, General References*;*

they link to the page the bookmark is on when the **Fit** *or* **FullScreen** *modes are used, otherwise to the exact spot.*
Labels *for figures must be placed* **after** *the* **caption** *to be correctly interpreted in* **LaTeX**. *Thus the caption should precede the commands for the* **label** *and the insertion of the figure.*

3. Graphics and Animations

We use our own software for differential geometry (cf.[7]). The software is written in **Borland PASCAL** and **Delphi**.
Its source code is available to the users. So it can be, and has been, extended, and is applicable in both teaching and research.
Here we deal with

3.1. The Basic Principles and Concepts of Our Software

The most important features of our software and its advantages over conventional graphics packages are

- **openness** – access to its source files
- **extendability** – to other areas, including research (cf. Figure 4)
- **use of line graphics** – the ability to draw arbitrary curves on surfaces, and lines of intersection (cf. Figures 5)
- **central projection** – free choice of parameters (cf. Figure 6, 7)
- **independent visibility checks** – to support visualisation (cf. Figure 8)
- **independence** – the concepts of our software can easily be transferred to other OOP languages (cf. Subsection 3.2)

Figure 4: Neighbourhoods in weak topologies

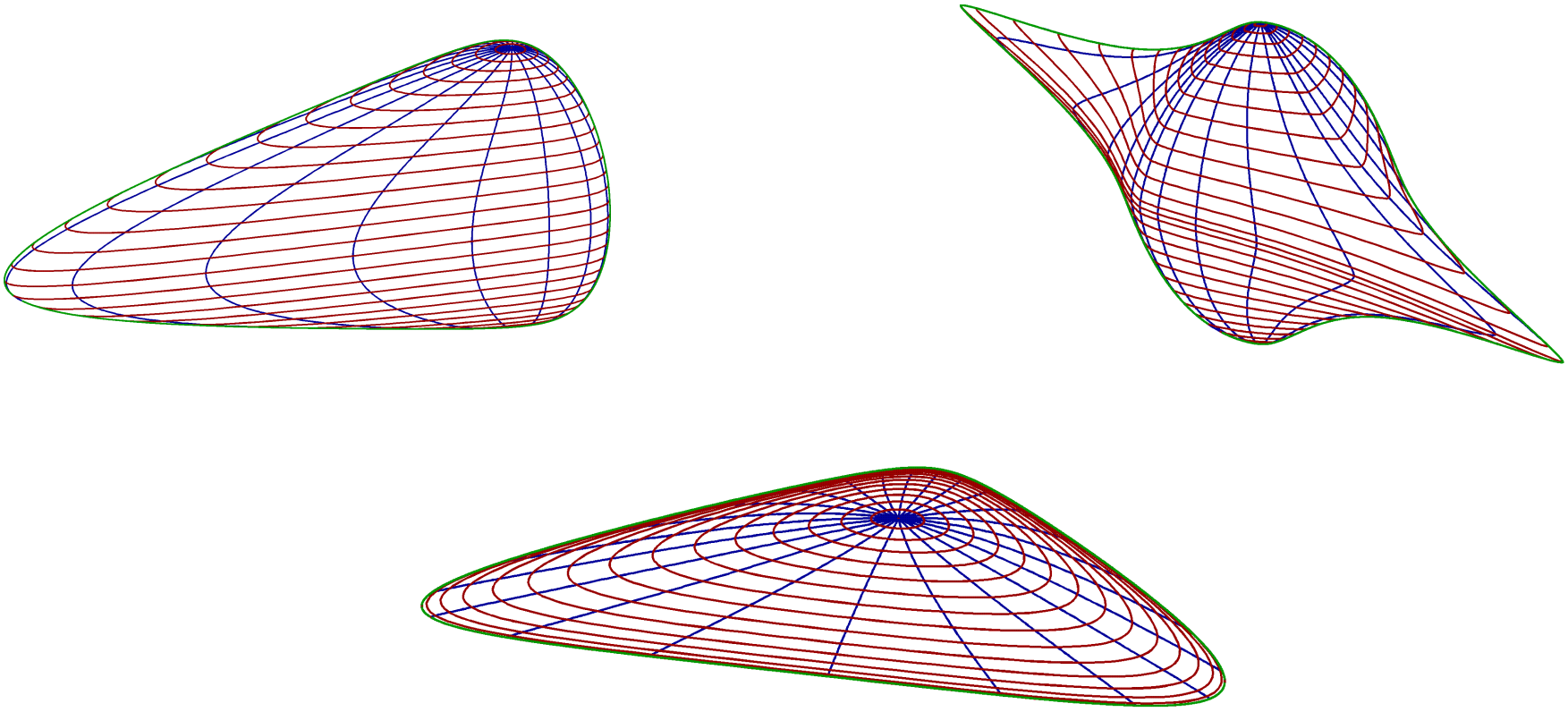
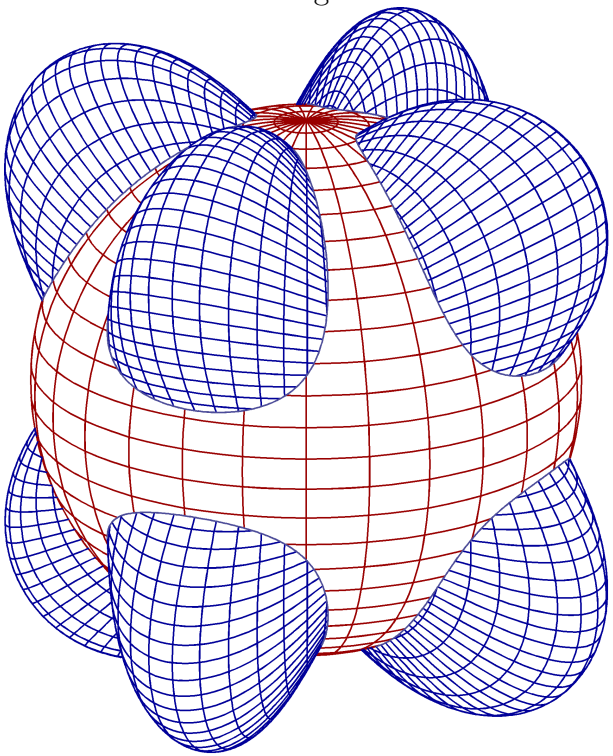


Figure 5: Lines of intersection of a sphere and a potential surface; asymptotic lines on a catenoid



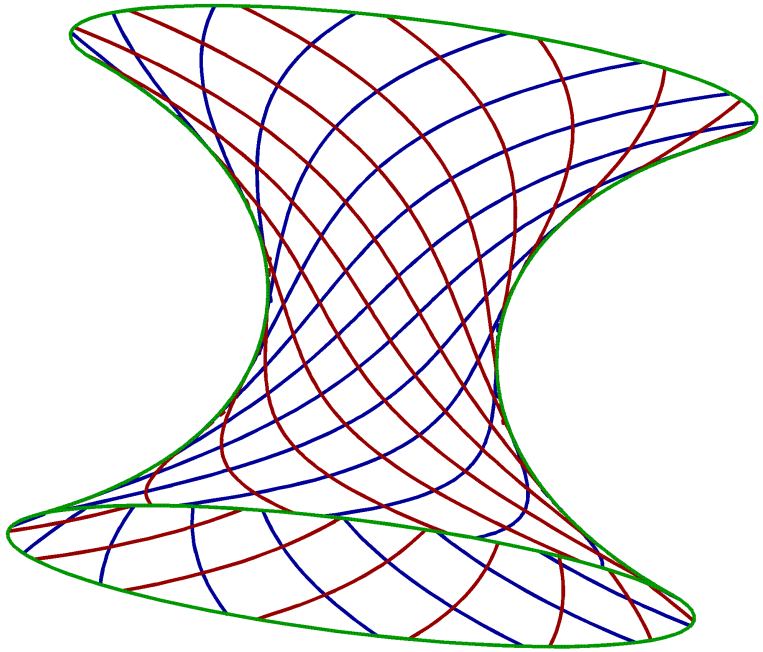


Figure 6: Central projection

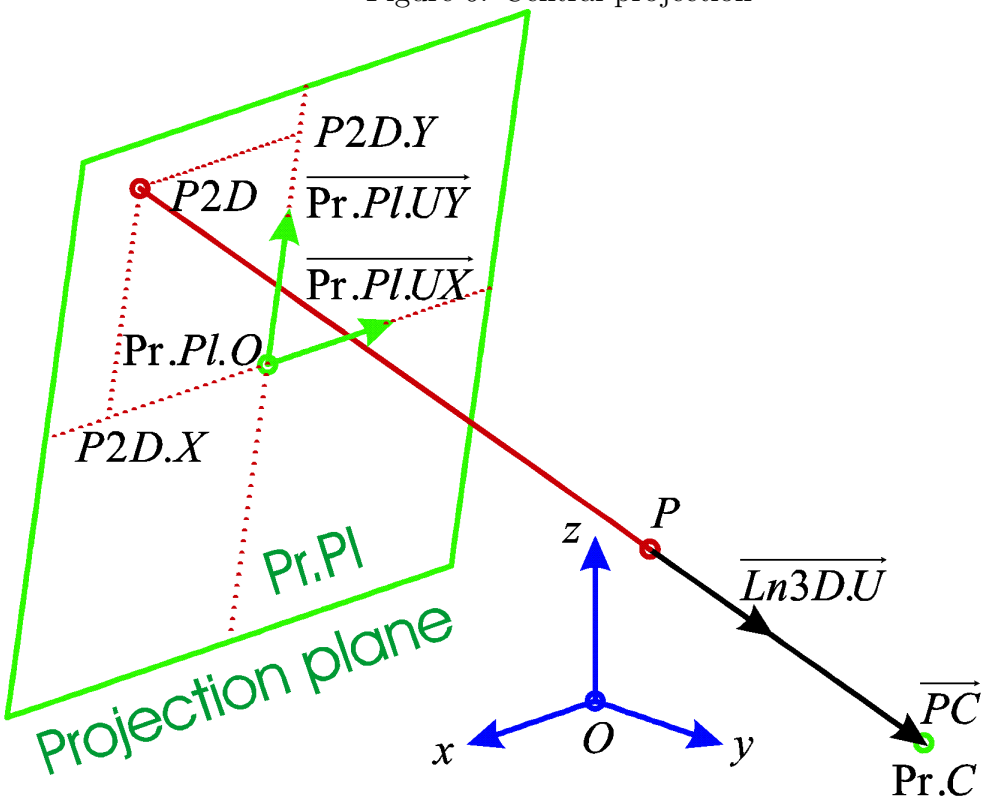
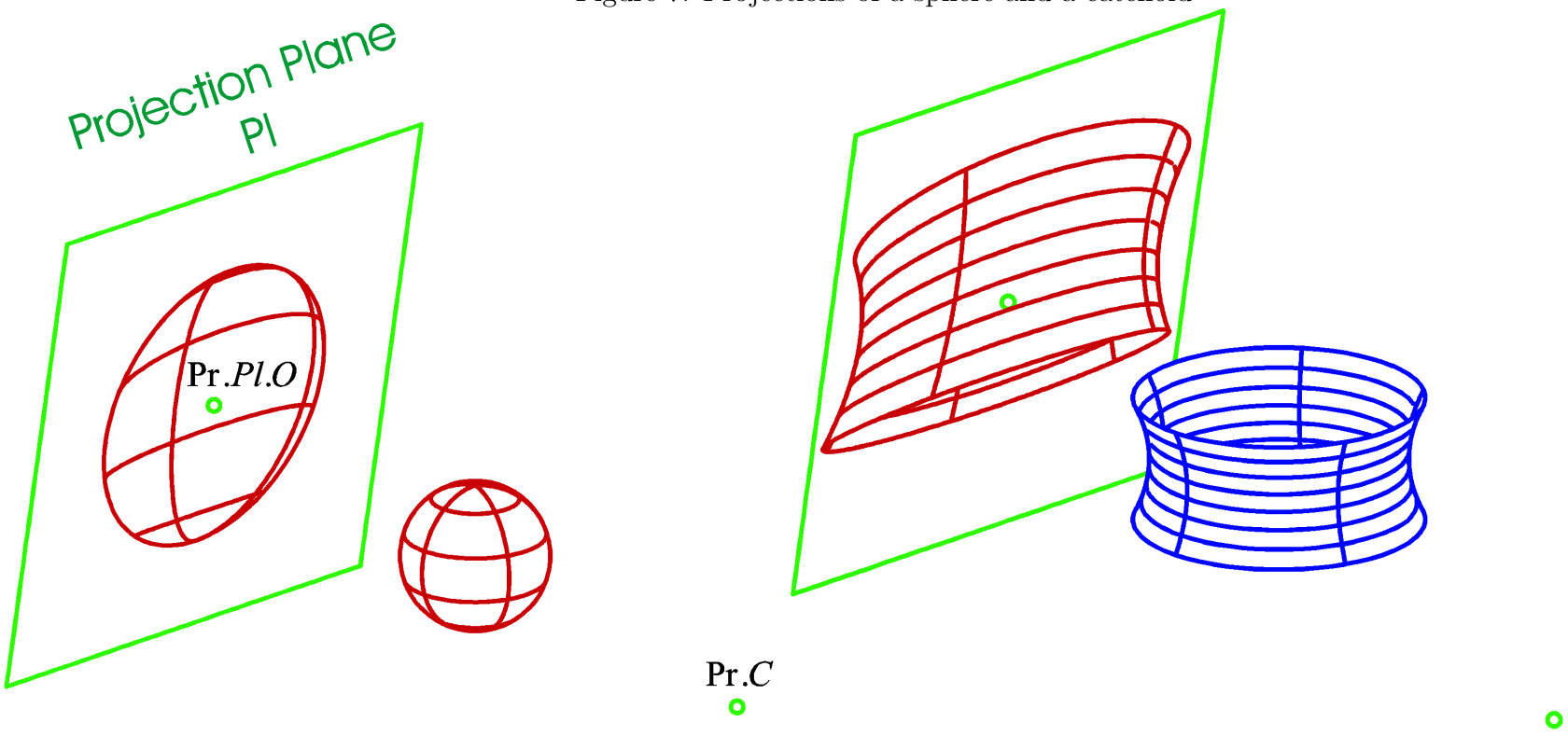


Figure 7: Projections of a sphere and a catenoid



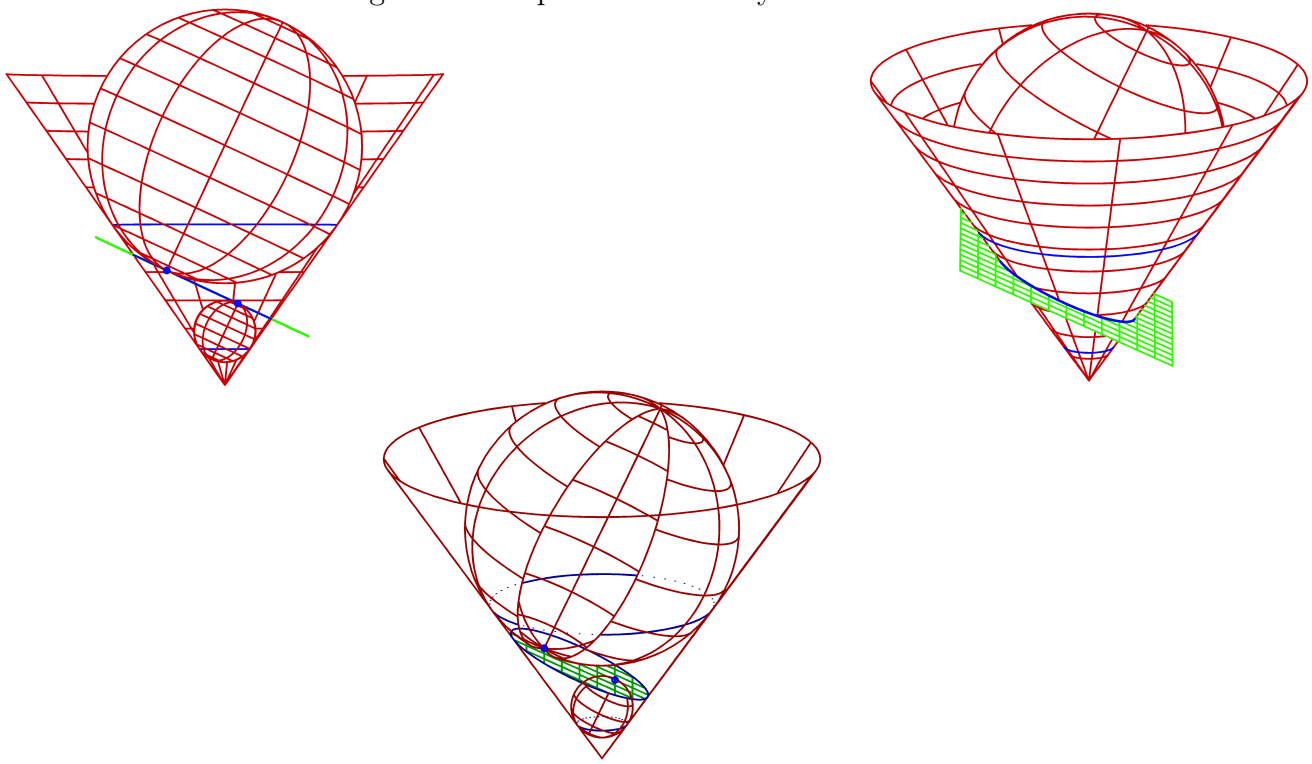
3.2. Exporting the Software

Our graphics can be exported to several formats such as

BMP, **PS**, **PLT**, **SCR**, or **GCLC**,

for instance PASCAL and PS file.
BMP and **SCR** are for raster graphics,
PS and **PLT** for vector graphics.
These formats can be converted to a number of other formats by means any graphics converter software.
GCLC (Geometry Constructions Language Converter) is a format to connect our software to the *GCLCWin graphics software package*.
Currently we are working on exporting our graphics to the **JVX** format to connect it to **JavaView** and **Mathematica**. 3.3

Figure 8: Independent visibility check



3.3. Including the Graphics

We include our graphics as follows:

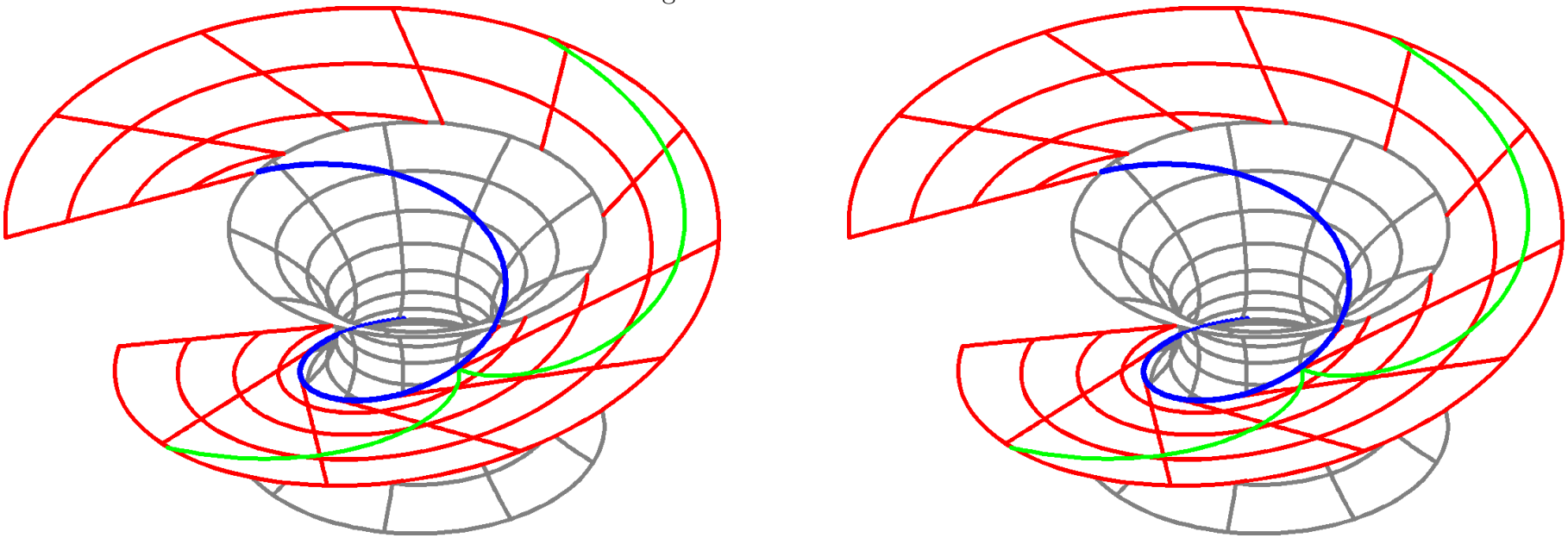
1. We take a **PS** file of the picture generated by our software
2. We use a graphics converter software, for instance **COREL DRAW** to convert the PS file to

   PNG format or

   EPS format for insertion in the **LaTeX**code.

We use **PNG** files, since they are much smaller for our graphics than **EPS** files. The sizes in Figure 9 are 22,471 (PNG) and 114,659 (EPS).

Figure 9: A PNG and EPS file



The command for inserting **PNG** files is

`\pdfimage width` *width* `height` *height* `depth` *depth* {*filename*}

It optionally changes the *width*, *height*, *depth*, or any combination of these attributes. The default values are zero for depth, and the natural size of the image for its width and height.

Remark 3.4 *(a) The admissible file extensions for the* pdfimage *command are* **PNG**, **PDF** *and* **JPEG**.
(b) The pdfimage command *is not normally accepted by* **LaTeX**, *for instance when creating a* **DVI** *file. Instead, the* `\includegraphics` *command of the* **graphicx** *package may be used. It does, however, not accept* **PNG** *files.*
(c) The `\includegraphics` *command is also accepted by* **PDFLATEX**, *but the extension* **EPS** *must be omitted from the filename.*

3.4. Creating Animations

We use the software package

Animagic GIF 32

to create an animation in

animated GIF format

from a number of **GIF** files of our graphics, and include the animation as an

animated GIF image in an *HTML* file.

Example **3.5** *Two animations*

An isometric map

An area preserving map

4. Interactive Graphics

Originally our graphics software package was a collection of programmes witten in

Borland PASCAL.

Recently Vesna Veličković translated the

PASCAL code to **Delphi**.

She also created a

user interface for interactive use

of our software. The users become independent of programming.

Finally, a look at our textbook

References

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