1. Introduction

elsarticle.cls is a thoroughly re-written document class for formatting LaTeX submissions to Elsevier journals. The class uses the environments and commands defined in LaTeX kernel without any change in the signature so that clashes with other contributed LaTeX packages such as hyperref.sty, preview-latex.sty, etc., will be minimal. elsarticle.cls is primarily built upon the default article.cls. The class depends on the following packages for its proper functionality:

1. pifont.sty for openstar in the title footnotes;
2. natbib.sty for citation processing;
3. geometry.sty for margin settings;
4. fleqn.clo for left aligned equations;
5. graphicx.sty for graphics inclusion;
6. txfonts.sty optional font package, if document is to be formatted with Times and compatible math fonts;
7. hyperref.sty optional packages if hyperlinking is required in the document.

All the above packages are part of any standard LaTeX installation. Therefore, the users need not be bothered about downloading any extra packages. Furthermore, users are free to make use of AMS math packages such as, amsmath.sty, amsthm.sty, amssymb.sty, amsfonts.sty, etc., if they want to. All these packages work in tandem with elsarticle.cls without any problems.

2. Major Differences

Following are the major differences between elsarticle.cls and its predecessor package, elsart.cls:

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- elsarticle.cls is built upon article.cls while elsart.cls is not. elsart.cls redefines many of the commands in the LaTeX classes/kernel, which can possibly cause surprising clashes with other contributed LaTeX packages;
- provides preprint document formatting by default, and optionally formats the document as per the final style of models 1+, 3+ and 5+ of Elsevier journals;
- some easier ways for formatting `list` and `theorem` environments are provided while people can still use amsthm.sty package;
- natbib.sty is the main citation processing package which can comprehensively handle all kinds of citations and works perfectly with hyperref.sty in combination with hypernat.sty.
- Long title pages are processed correctly in preprint and final formats.

3. Installation

The package is available at author resources page at Elsevier (`http://www.elsevier.com/locate/latex`). It can also be found in any of the nodes of the Comprehensive TeX Archive Network (CTAN), one of the primary nodes being `http://tug.ctan.org/tex-archive/macros/latex/contrib/elsarticle/` Please download the elsarticle.dtx which is the composite class with documentation and elsarticle.ins which is the LaTeX installer file. When we compile the elsarticle.ins with LaTeX it provides the class file, elsarticle.cls by stripping off all the documentation from the `*.dtx` file. The class may be moved or copied to a place, usually, `$TEXMF/tex/latex/elsevier/`, or a folder which will be read by LaTeX during document compilation. The TeX file database needs updation after moving/copying class file. Usually, we use commands like `mktexlsr` or `texhash` depending upon the distribution and operating system.

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4. Usage

The class should be loaded with the command:

```
\documentclass[<options>]{elsarticle}
```

where the `options` can be the following:

(1) `preprint` — default options which formats the document for submission to Elsevier journals.

(2) `review` — similar to `preprint` option, but increases the baselineskip to facilitate easier review process.

(3) `1p` — formats the article to the look and feel of the final format of model 1+ journals. This is always single column style.

(4) `3p` — formats the article to the look and feel of the final format of model 3+ journals. If the journal is a two column model, use `twocolumn` option in combination.

(5) `5p` — formats for model 5+ journals. This is always two column style.

(6) `authoryear` — author-year citation style of natbib.sty. If you want to add extra options of natbib.sty, you may use the options as a comma delimited strings as argument to `\biboptions` command. An example would be:

```
\biboptions{longnamesfirst,angle,semicolon}
```

(7) `number` — numbered citation style. Extra options can be loaded with `\biboptions` command.

(8) `sort&compress` sorts and compresses the numbered citations. For example, citation [1,2,3] will become [1–3].

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(9) `longtitle` — if front matter is unusually long, use this option to split the title page across pages with the correct placement of title and author footnotes in the first page.

(10) `times` — loads txfonts.sty if available in the system to use Times and compatible math fonts.

(11) All options of article.cls can be used with this document class.

(12) The default options loaded are `a4paper`, `10pt`, `oneside`, `onecolumn` and `preprint`.

5. Frontmatter

There are two types of frontmatter coding:

(1) each author is connected to an affiliation with a footnote marker; hence all authors are grouped together and affiliations follow;

(2) authors of same affiliations are grouped together and the relevant affiliation follows this group. An example coding of the first type is provided in the next page.

```
\title{This is a specimen title\tnoteref{t1,t2}}
\tnotetext[t1]{This document is a collaborative effort.}
\tnotetext[t2]{The second title footnote which is a longer
longer than the first one and with an intention to fill
in up more than one line while formatting.}
```

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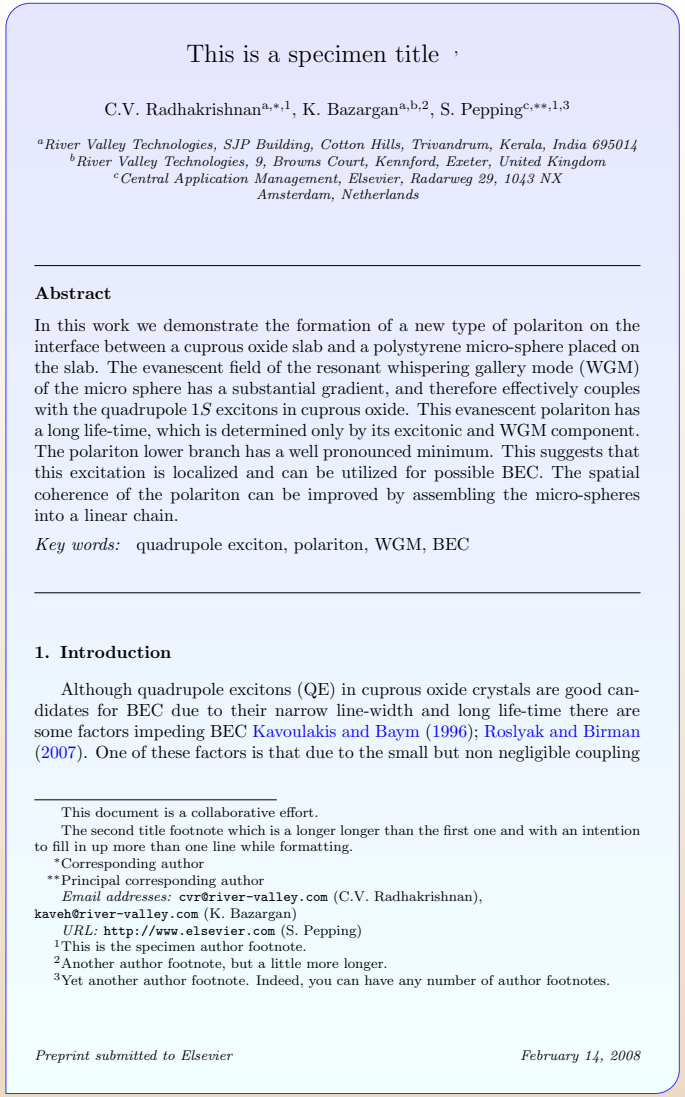
```
\author[rvt]{C.V.~Radhakrishnan\corref{cor1}\fnref{fn1}}
\ead{cvr@river-valley.com}

\author[rvt,focal]{K.~Bazargan\fnref{fn2}}
\ead{kaveh@river-valley.com}

\author[els]{S.~Pepping\corref{cor2}\fnref{fn1,fn3}}
\ead[url]{http://www.elsevier.com}
```

```
\cortext[cor1]{Corresponding author}
\cortext[cor2]{Principal corresponding author}
\fntext[fn1]{This is the specimen author footnote.}
\fntext[fn2]{Another author footnote, but a little more longer.}
\fntext[fn3]{Yet another author footnote. Indeed, you can have
any number of author footnotes.}
```

```
\address[rvt]{River Valley Technologies, SJP Building,
Cotton Hills, Trivandrum, Kerala, India 695014}
\address[focal]{River Valley Technologies, 9, Browns Court,
Kennford, Exeter, United Kingdom}
\address[els]{Central Application Management,
Elsevier, Radarweg 29, 1043 NX\\
Amsterdam, Netherlands}
```

You can see the output in the panel to the right.

Most of the commands like `\title`, `\author`, `\address` are self explanatory. Various components are linked to each other by a label–reference mechanism;



This is a specimen title ,

C.V. Radhakrishnan[a,*,1], K. Bazargan[a,b,2], S. Pepping[c,**,1,3]

[a] *River Valley Technologies, SJP Building, Cotton Hills, Trivandrum, Kerala, India 695014*
[b] *River Valley Technologies, 9, Browns Court, Kennford, Exeter, United Kingdom*
[c] *Central Application Management, Elsevier, Radarweg 29, 1043 NX Amsterdam, Netherlands*

Abstract

In this work we demonstrate the formation of a new type of polariton on the interface between a cuprous oxide slab and a polystyrene micro-sphere placed on the slab. The evanescent field of the resonant whispering gallery mode (WGM) of the micro sphere has a substantial gradient, and therefore effectively couples with the quadrupole $1S$ excitons in cuprous oxide. This evanescent polariton has a long life-time, which is determined only by its excitonic and WGM component. The polariton lower branch has a well pronounced minimum. This suggests that this excitation is localized and can be utilized for possible BEC. The spatial coherence of the polariton can be improved by assembling the micro-spheres into a linear chain.

Key words: quadrupole exciton, polariton, WGM, BEC

1. Introduction

Although quadrupole excitons (QE) in cuprous oxide crystals are good candidates for BEC due to their narrow line-width and long life-time there are some factors impeding BEC Kavoulakis and Baym (1996); Roslyak and Birman (2007). One of these factors is that due to the small but non negligible coupling

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*Corresponding author
**Principal corresponding author
Email addresses: cvr@river-valley.com (C.V. Radhakrishnan), kaveh@river-valley.com (K. Bazargan)
URL: http://www.elsevier.com (S. Pepping)
[1] This is the specimen author footnote.
[2] Another author footnote, but a little more longer.
[3] Yet another author footnote. Indeed, you can have any number of author footnotes.

Preprint submitted to Elsevier *February 14, 2008*

for instance, title footnote is linked to the title with a footnote mark generated by referring to the `\label` string of the `\tnotetext`. We have used similar commands such as `\tnoteref` (to link title note to title); `\corref` (to link corresponding author text to corresponding author); `\fnref` (to link footnote text to the relevant author names). TEX needs two compilations to resolve the footnote marks in the frontmatter part. Given below are the syntax of various note marks and note texts.

```
\tnoteref{<label(s)>}
\corref{<label(s)>}
\fnref{<label(s)>}
\tnotetext[<label>]{<title note text>}
\cortext[<label>]{<corresponding author note text>}
\fntext[<label>]{<author footnote text>}
```

where `<label(s)>` can be either one or more comma delimited label strings. The optional arguments to the `\author` command holds the ref label(s) of the address(es) to which the author is affiliated while each `\address` command can have an optional argument of a label. In the same manner, `\tnotetext`, `\fntext`, `\cortext` will have optional arguments as their respective labels and note text as their mandatory argument.

The following example code provides the markup of the second type of author-affiliation as seen in the output given in the box to the right.

```
\author{C.V.~Radhakrishnan\corref{cor1}\fnref{fn1}}
\ead{cvr@river-valley.com}
\address{River Valley Technologies, SJP Building,
Cotton Hills, Trivandrum, Kerala, India 695014}
```

This is a specimen title [,]

C.V. Radhakrishnan[*,1]

River Valley Technologies, SJP Building, Cotton Hills, Trivandrum, Kerala, India 695014

K. Bazargan[2]

River Valley Technologies, 9, Browns Court, Kennford, Exeter, United Kingdom

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Abstract

In this work we demonstrate the formation of a new type of polariton on the interface between a cuprous oxide slab and a polystyrene micro-sphere placed on the slab. The evanescent field of the resonant whispering gallery mode (WGM) of the micro sphere has a substantial gradient, and therefore effectively couples with the quadrupole 1*S* excitons in cuprous oxide. This evanescent polariton has a long life-time, which is determined only by its excitonic and WGM component. The polariton lower branch has a well pronounced minimum. This suggests that this excitation is localized and can be utilized for possible BEC. The spatial coherence of the polariton can be improved by assembling the micro-spheres into a linear chain.

Key words: quadrupole exciton, polariton, WGM, BEC

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The second title footnote which is a longer longer than the first one and with an intention to fill in up more than one line while formatting.

*Corresponding author

Email addresses: cvr@river-valley.com (C.V. Radhakrishnan), kaveh@river-valley.com (K. Bazargan)

URL: http://www.elsevier.com (S. Pepping)

[1]This is the first author footnote.

[2]Another author footnote, this is a very long footnote and it should be a really long footnote. But this footnote is not yet sufficiently long enough to make two lines of footnote text.

[3]Yet another author footnote.

```
\author{K.~Bazargan\fnref{fn2}}
\ead{kaveh@river-valley.com}
\address{River Valley Technologies, 9, Browns Court, Kennford,
Exeter, UK.}
```

```
\author{S.~Pepping\fnref{fn1,fn3}}
\ead[url]{http://www.elsevier.com}
\address{Central Application Management,
Elsevier, Radarweg 43, 1043 NX Amsterdam, Netherlands}
```

```
\cortext[cor1]{Corresponding author}
\fntext[fn1]{This is the first author footnote.}
\fntext[fn2]{Another author footnote, this is a very long footnote and
it should be a really long footnote. But this footnote is not yet
sufficiently long enough to make two lines of footnote text.}
\fntext[fn3]{Yet another author footnote.}
```

The frontmatter part has further environments such as abstract and keywords. These can be marked up in the following manner:

```
\begin{abstract}
In this work we demonstrate the formation of a new type of
polariton on the interface between a ....
\end{abstract}
```

```
\begin{keyword}
quadruple exiton \sep polariton \sep WGM\sep BEC
\end{keyworkd}
```

This is a specimen title [*]

C.V. Radhakrishnan[*,1]

River Valley Technologies, SJP Building, Cotton Hills, Trivandrum, Kerala, India 695014

K. Bazargan[2]

River Valley Technologies, 9, Browns Court, Kennford, Exeter, United Kingdom

S. Pepping[1,3]

Central Application Management, Elsevier, Radarweg 29, 1043 NX Amsterdam, Netherlands

Abstract

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Key words: quadrupole exciton, polariton, WGM, BEC

[*] This document is a collaborative effort.

[,] The second title footnote which is a longer longer than the first one and with an intention to fill in up more than one line while formatting.

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URL: http://www.elsevier.com (S. Pepping)

[1]This is the first author footnote.

[2]Another author footnote, this is a very long footnote and it should be a really long footnote. But this footnote is not yet sufficiently long enough to make two lines of footnote text.

[3]Yet another author footnote.

Each keyword shall be separated by `\sep` command. MSC classifications shall be provided in the keyword environment with the commands `\MSC`. `\MSC` accepts an optional argument to accommodae future revisions. eg., `\MSC[2008]`. The default is 2000.

6. Floats

Figures may be included using the command, `\includegraphics` in combination with or without its several options to further control graphic. `\includegraphics` is provided by graphic[s,x].sty which is part of any standard LaTeX distribution. graphicx.sty is loaded by default. LaTeX accepts figures in postscript format while pdfLaTeX accepts *.pdf, *.mps (metapost), *.jpg and *.png formats. pdfLaTeX does not accept graphic files in postscript format.

The `table` environment is handy for marking up tabular material. If users want to use multirow.sty, array.sty, etc., to fine control/enhance the tables, they are welcome to load any package of their choice and elsarticle.cls will work in combination with all loaded packages.

7. Theorem and theorem like environments

elsarticle.cls provides a few shortcuts to format theorems and theorem-like environments with ease. In all commands the options that are used with `\newtheorem` command will work exactly in the same manner. elsarticle.cls provides three commands to format theorem or theorem-like environments:

```
\newtheorem{thm}{Theorem}
\newtheorem{lem}[thm]{Lemma}
\newdefinition{rmk}{Remark}
\newproof{pf}{Proof}
\newproof{pot}{Proof of Theorem \ref{thm2}}
```


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`\newtheorem` command formats a theorem in LaTeX's default style with italicized font, bold font for theorem heading and theorem number at the right hand side of the theorem heading. It also optionally accepts an argument which will be printed as an extra heading in parentheses. You may roll over your mouse here to see how some text enclosed between `\begin{thm} ... \end{thm}` will look like.

`\newdefinition` command is same in all respects as its `\newtheorem` counterpart except that the font shape is roman instead of italic. Both `\newdefinition` and `\newtheorem` commands automatically defines counters for the environments defined. See the output of of `\begin{rmk} ... \end{rmk}`.

`\newproof` command is for defining proof environments with upright font shape. No counters are defined. See the output of `\begin{pot} ... \end{pot}`.

Users can also make use of `amsthm.sty` which will override all the default definitions described above.

8. Enumerated and Itemized Lists

elsarticle.cls provides an extended list processing macros which makes the usage a bit more user friendly than the default LaTeX list macros. With an optional argument to the `\begin{enumerate}` command, you can change the list counter type and its attributes.

```
\begin{enumerate}[1.]
\item The enumerate environment starts with an optional argument
'1.' so that the item counter will be suffixed by a period.
\item You can use '(a)' for alphabetical counter and '(i)' for
roman counter.
```


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```
\begin{enumerate}[a)]
\item Another level of list with alphabetical counter.
\item One more item before we start another.
```

```
\begin{enumerate}[(i)]
\item This item has roman numeral counter.
\item Another one before we close the third level.
\end{enumerate}
\item Third item in second level.
\end{enumerate}
\item All list items conclude with this step.
\end{enumerate}
```

Roll over your mouse here to see the typeset copy of the above code. Furthermore, the enhanced list environment allows one to prefix a string like 'step' to all the item numbers. Take a look at the example below:

```
\begin{enumerate}[Step 1.]
\item This is the first step of the example list.
\item Obviously this is the second step.
\item The final step to wind up this example.
\end{enumerate}
```

Here is the typeset output of the above example code.

9. Cross-references

In electronic publications, articles may be internally hyperlinked. Hyperlinks are generated from proper cross-references in the article. For example, the

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words Fig. 1 will never be more than simple text, whereas the proper cross-reference `\ref{tiger}` may be turned into a hyperlink to the figure itself: Fig. 1. In the same way, the words Ref. [1] will fail to turn into a hyperlink; the proper cross-reference is `\cite{Knuth96}`. Cross-referencing is possible in LaTeX for sections, subsections, formulae, figures, tables, and literature references.

10. Mathematical symbols and formulae

Many physical/mathematical sciences authors require more mathematical symbols than the few that are provided in standard LaTeX. A useful package for additional symbols is the amssymb package, developed by the American Mathematical Society. This package includes such oft-used symbols as `\lesssim` for $\lesssim$, `\gtrsim` for $\gtrsim$ or `\hbar` for $\hbar$. Note that your TeX system should have the msam and msbm fonts installed. If you need only a few symbols, such as `\Box` for $\Box$, you might try the package latexsym.

Another point which would require authors' attention is the breaking of longer equations. When you use elsarticle.cls for formatting your submissions in `preprint` mode, the document is formatted in single column style with a text width of 384pt or 5.3in. When this document is formatted for final print and if the journal happens to be a double column journal, the text width will be reduced to 224pt at for 3+ double column and 5+ journals respectively. All the nifty fine-tuning in equation breaking done by the author goes to waste in such cases. Therefore, authors are requested to check this problem by typesetting their submissions in final format as well just to see if their equations are broken at appropriate places, by changing appropriate options in the document class loading command, which is explained in section 4, Usage. This allows authors to fix any equation breaking problem before submission for publication. elsarticle.cls supports formatting the author submission in different types of final format. This is further discussed in section 12, Final print.

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11. Bibliography

Three bibliographic style files (`*.bst`) are provided — elsarticle-num.bst, elsarticle-num-names.bst and elsarticle-harv.bst — the first one for the numbered scheme, the second for the numbered with new options of natbib.sty and the last one for the author year scheme.

In LaTeX literature references are listed in the `thebibliography` environment. Each reference is a `\bibitem` and each `\bibitem` is identified by a label, by which it can be cited in the text:

`\bibitem[Elson et al.(1996)]{ESG96}` is cited as `\citet{ESG96}`.

In connection with cross-referencing and possible future hyperlinking it is not a good idea to collect more that one literature item in one `\bibitem`. The so-called Harvard or author-year style of referencing is enabled by the LaTeX package natbib. With this package the literature can be cited as follows:

- Parenthetical: `\citep{WB96}` produces (Wettig & Brown, 1996).
- Textual: `\citet{ESG96}` produces Elson et al. (1996).
- An affix and part of a reference: `\citep[e.g.][Ch. 2]{Gea97}` produces (e.g. Governato et al., 1997, Ch. 2).

In the numbered scheme of citation, `\cite{<label>}` is used, since `\citep` or `\citet` has no relevance in numbered scheme. natbib package is loaded by elsarticle with `numbers` as default option. You can change this to author-year or harvard scheme by adding option `authoryear` in the class loading command. If you want to use more options of the natbib package, you can do so with the `\biboptions` command, which is described in section 4, Usage. For details of various options of the natbib package, please take a look at the natbib documentation, which is part of any standard LaTeX installation.

In addition to the above standard `.bst` files, there are 10 journal-specific `.bst` files also available. Instruction for using these `.bst` files can be found at http://support.river-valley.com

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Displayed equations and double column journals

Many Elsevier journals print their text in two columns. Because the preprint layout uses a larger line width than such columns, the formulas are too wide for the line width in print. Here is an example of an equation (see equation 6) which is perfect in single column preprint format:

Clip 1: See equation (6).

$$\mathbf{M}_{1,39} = A^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{M}_{ml} + B^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{N}_{ml} \tag{4}$$

Here $A^{ml}_{1,39}$ and $B^{ml}_{1,39}$ are the translational coefficients. Their explicit expression can be found, for instance, in Fuller (1991); Miyazaki and Jimba (2000) and are explicitly listed in the Appendix.

The bulk (incident) and evanescent polaritons in cuprous oxide are formed through the quadrupole part of the light-matter interaction:

$$\mathbf{M}_{1,39} = A^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{M}_{ml} + B^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{N}_{ml} \tag{5}$$

Here e, m are the electron charge and mass; $\mathbf{p}$ is the electron momentum. For the quadrupole $1S$ transition in cuprous oxide the energy of interaction can be written as:

$$\sum_{i=0}^{\infty} A^n \int \mathrm{d}x\, \frac{F_n(x)}{A_n + B_n} = B^n C^n \int \mathrm{d}x \int \mathrm{d}y\, \frac{G_n(x,y)}{\mathcal{A}_n x + \mathcal{B}_n y} + \frac{G_n(x,y)}{\mathcal{A}_n x + \mathcal{B}_n y} \tag{6}$$

When this document is typeset for publication in a model 3+ journal with double columns, the equation will overlap the second column text matter if the equation is not broken at the appropriate location.

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Clip 2: See equation (6) overprints into second column.

Fuller (1991); Miyazaki and Jimba (2000) and are explicitly listed in the Appendix.

The bulk (incident) and evanescent polaritons in cuprous oxide are formed through the quadrupole part of the light-matter interaction:

$$\mathbf{M}_{1,39} = A^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{M}_{ml} + B^{ml}_{1,39}\,(r_0 + \delta r)\,\mathbf{N}_{ml} \quad (5)$$

Here e, m are the electron charge and mass; $\mathbf{p}$ is the electron momentum. For the quadrupole $1S$ transition in cuprous oxide the energy of interaction can be written as:

$$\sum_{i=0}^{\infty} A^n \int \mathrm{d}x\, \frac{F_n(x)}{A_n + B_n} = B^n C^n \int \mathrm{d}x \int \mathrm{d}y\, \frac{G_n(x,y)}{\mathcal{A}_n x + \mathcal{B}_n y} + \frac{G_n(x,y)}{\mathcal{A}_n x + \mathcal{B}_n y} \quad (6)$$

Here we introduced the initial state of the system, which penetrating into cuprous oxide, although the coupling grows with mode number l, because the gradient of the evanescent field increases. Note that QE realizes *strong* coupling regime $g_{1,39} > \gamma$ while DE demonstrates *weak* regime only Xudong Fan (1999). The property of the scalable coupling factor can be utilized in practical applications such as non-linear optics and is the subject of our future work.

3. Results and discussion

In this section let us utilize the above calculated WGM-QE interaction to obtain the evanescent polariton dispersion in the framework of the coupled oscillator model that has been widely used for describing coupled atom-photon or exciton-photon modes in micro-

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C.V. Radhakrishnan[a,*,1], K. Bazargan[a,b,2], S. Pepping[c,**,1,3]

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Abstract

In this work we demonstrate the formation of a new type of polariton on the interface between a cuprous oxide slab and a polystyrene micro-sphere placed on the slab. The evanescent field of the resonant whispering gallery mode (WGM) of the micro sphere has a substantial gradient, and therefore effectively couples with the quadrupole 1*S* excitons in cuprous oxide. This evanescent polariton has a long life-time, which is determined only by its excitonic and WGM component. The polariton lower branch has a well pronounced minimum. This suggests that this excitation is localized and can be utilized for possible BEC. The spatial coherence of the polariton can be improved by assembling the micro-spheres into a linear chain.

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Clip 4: Lower part of first page of a single column article.

Key words: quadrupole exciton, polariton, WGM, BEC

1. Introduction

Although quadrupole excitons (QE) in cuprous oxide crystals are good candidates for BEC due to their narrow line-width and long life-time there are some factors impeding BEC Kavoulakis and Baym (1996); Roslyak and Birman (2007). One of these factors is that due to the small but non negligible coupling to the photon bath, one must consider BEC of the corresponding mixed light-matter states called polaritons Frohlich et al. (2005). The photon-like part of the polariton has a large group velocity and tends to escape from the crystal. Thus, the temporal coherence of the condensate is effectively broken Ell et al. (1998); Snoke (2002). One proposed solution to

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Clip 5: Upper part of first page of a typical double column article.

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Therefore in this work we propose to prevent the polariton escaping by trapping it into a whispering gallery mode (WGM)[4] of a polystyrene micro-sphere (PMS).

We develop a model which demonstrates formation of a strongly *localized* polariton-like quasi-particle. This quasi-particle is formed by the *resonant* interaction between the WGM in PMS and QE in the adjacent layer of cuprous oxide. The QE interacts with the *gradient* of the WGM evanescent field

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Clip 6: Lower part of first page a typical double column article.

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There are few experiments concerned with resonant interaction of the WGM and dipole allowed exciton (DE) Xudong Fan (1999); Fan et al. (1999). But the DE has some disadvantages compared to QE when it comes to interaction with the WGM. First, the evanescent light has small intensity. Therefore it is not effective for the

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[4] WGM occur at particular resonant wavelengths of light for a given dielectric sphere size. At these wavelengths, the light undergoes total internal reflection at the sphere surface and becomes trapped within the particle for timescales of the order of ns.

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